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CARDINAL PROCESS OF PRODUCTIDAE

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ABSTRACT—This paper attempts to outline the phylogeny of the Productidae from a study of the cardinal process development and to point out the taxonomic value of this shell feature. The structure is described for each genus of which we have been able to obtain specimens showing the process. Brief descriptions have been quoted for genera of which no suitable specimens have been available for study but which have been described by others. The remaining genera have been omitted from the discussion. Phylogeny as determined on the cardinal process agrees fairly closely with that worked out on external characters. It is concluded that the cardinal process is of considerable taxonomic value and can serve as a generic characteristic although present knowledge may not warrant the use of this feature for definition of species.

INTRODUCTION

DURING the last five years the senior author has devoted considerable study to the family Productidae, especially genera of the Mississippian period and has come to realize that the very distinctly developed cardinal processes must be of considerable significance. The prominence and probable importance of the structure have been noted also by Dunbar and Condra in their study of Pennsylvanian Brachiopoda (1932, p. 183). In other literature on this family, various opinions on the development and significance of the cardinal process also have been expressed. The purpose of this investigation was to study the cardinal process of as many genera of Productidae as possible in order to determine its taxonomic value and importance in deciphering the phylogeny of the family.

The cardinal process is a raised, and sometimes complex, structure on the hinge line of the dorsal valve in many brachiopods which functions as an attachment for the diductor muscles stretching from the pedicle valve. The principal diductors are attached to the anterior part of the process and the accessory diductors to the posterior part. Because the muscle scars of these attachments are seldom discernible on the cardinal process, little mention has been made of them. The cardinal process rises from the notothyrial platform slightly below the hinge line on the interior or ventral side of the valve. It begins a little below the hingeline and extends above it, thus allowing the process to act as a lever with the hinge teeth as a fulcrum, so that constriction of the muscles opens the valves.

Because the process is an internal structure of the dorsal valve, not many specimens are preserved in such a manner that it can be observed. Suitable material has not been available for the study of this feature of several genera of the family. However the literature on the group has provided brief descriptions and a few illustrations of some of the genera not available to us. The remain-

ing forms must for the present be omitted from consideration although it is hoped that they may be investigated at some future time when satisfactory material for their study may be procured. The quantity of material available for study, although limited in comparison with the large number of specimens known, leads us to the conclusion that this shell feature is constant enough in different types of Productidae to be a reliable generic determinant.

Its value as a specific character is not so well established. Although the available specimens of several genera show considerable variations, it has not been possible as yet to demonstrate that certain varieties of the process in different members of the same genus can be correlated with other characters, such as external shell features or other internal characters, so that a given species can be recognized either from the process or from other associated characters. As more specimens become available and are studied, it may be possible to show that there is a constant, definite relationship between the cardinal process and other characters which will enable workers to identify species within a genus from the process alone, as well as from other characters.

A set of terms is necessary in referring to the different surfaces of the cardinal process. That surface facing the interior of the shell or the ventral valve is referred to as the ventral surface. The term dorsal is applied to the surface of the process away from the ventral valve. Many of the processes have a surface on the distal end approximately normal to these two which is called, because of its position, the posterior surface, but in most forms, when a change in position occurs, a part of the ventral surface becomes the posterior surface.

DESCRIPTIONS

Family PRODUCTIDAE Gray
Subfamily PRODUCTELLINAE Schuchert and Lavene emend. Sutton
Genus PRODUCTELLA Hall, 1867
Plate 53, figures 1–5

The cardinal process of *Productella* projects beyond the posterior margin of the valve to a distance of about one millimeter. It is developed on a platform produced by the junction of the medium septum and the marginal ridges. The process is typically bilobed with a rather deep dividing sulcus. At the distal extremity of each lobe is a small furrow, which is prominent on the dorsal face and divides that side of the lobe into two small apophyses but is not developed on the ventral surface. At the base of the process on the ventral side is a small pit which Muir-Wood (1928, p. 13) suggested may be an anal opening. The pit is not present on the external surface of the valve.

Only two species of the genus, *Productella pyxidata* (Hall) and *P. hallana* (Walcott) have been studied. *Productella pyxidata* is the most typical species of the genus, and *P. hallana* seems to be most primitive. *P. hallana* has two widely diverging lobes which are rather flat with clefts of the extremities only on the dorsal surface. The chief difference between the two species is the widely diverging lobes of *P. hallana* as compared with the almost vertical lobes of *P. pyxidata*.

Genus LEPTALOSIA Dunbar and Condra, 1932

The following description of the cardinal process is quoted from Dunbar and Condra (1932, p. 260):

> The cardinal process is very small and bifid being composed of two narrow, posteriorly facing, and closely appressed muscular apophyses, supported in front by a pair of very short diverging ridges separated by a depression. Muscular and vascular impressions are very faintly impressed and usually not distinguishable.

Genus STROPHALOSIA King, 1844

The following description is taken from the paper by Hinchey and Ray (1935, p. 249):

> The cardinal process is erect, anteriorly bifid, posteriorly trifid, supported laterally by the socket plates and confluent with a well defined medium septum.

Genus HETERALOSIA M. H. King, 1938

King (1938, p. 278) made the following comment in his discussion of the genus:

> In the dorsal valve the dental sockets are deep and the cardinal process is long and narrow.

Other Genera

The internal structures of the dorsal valves of *Productina* Sutton, 1938 and *Gigantella* Saryteheval, 1928 are unknown.

Subfamily PRODUCTINAE Waagen, emend. Sutton
Genus PRODUCTUS Sowerby, 1814
Plate 54, figure 9

The cardinal process of *Productus*, when viewed from the interior of the valve, appears to be a simple undivided structure which is strongly developed at the base and extends anteriorly to become the medium septum and laterally to become prominent ridges following the hinge margin. It projects straight outward from the hingeline with the posterior surface extending at a right angle to the exterior of the valve. On the ventral surface of the process there is a small sulcus which is more pronounced toward the distal end, and forms a pair of slight apophyses on the ventral surface at the end of the process. The sulcus extends toward the exterior of the dorsal side and there appears to divide the center lobe. Two deep and prominent sulci, that divide two side lobes from the center, extend down the posterior surface to the dorsal side and form a typical trifid process. The molds of the dorsal side of the process indicate that there is a continuation of the sulci to the base of the structure.

The size of the process is proportional to the size of the shell. Smaller specimens show less separation of the different lobes toward the ventral side and also have a smaller extension of the process toward the exterior side. Broken fragments of the process exhibit a well-defined layering of the material which gives an interesting clue to the development from a small knob-like structure to the more complicated process.

Genus DICTYOCLOSTUS Muir-Wood, 1930
Plate 54, figures 2–8

The cardinal process of *Dictyoclostus* is a typical trifid form which is large because most specimens of this group are of considerable size. The process rises from the junction of the widened medium septum and the enlarged, laterally supported, marginal ridges. The marginal ridges broaden toward the cardinal extremities, flatten out, and continue around the margin of the valve.

The average process is about 3 mm. wide at the base, has a maximum width of about 6 mm., and extends about 5 mm. beyond the hingeline. Unlike the process of *Productus*, the ventral surface slopes forward to the dorsal side which is in a plane with the hingeline. The junction of the two surfaces produces a chisellike posterior end of the process. Just above the hingeline are two projections which extend outward at an angle to the main axis of the process and form the outer lobes of the trifid process. These lobes also project ventrally beyond the general surface of the process. The side lobes are unusual in that the separation from the main lobe is almost at right angles in many specimens. In all specimens the angle between the center lobe and side lobes is greater than in other members of the Productidae. The surface of the center lobe on some specimens is flat and in other forms it contains a median furrow. There is, on the dorsal surface, a series of striations, or growth lines, horizontal on the center lobe and vertical on the side lobes. Below the lobes of the process on the dorsal side is a ridge which extends vertically from the junction of the side lobes to the hingeline. This ridge projects forward at the hingeline in a hook-like process whose probable function was to catch in the beak of the pedicle valve.

There are considerable variations among the members of the genus with respect to the angles of the side lobes and their protrusion beyond the ventral surface of the process, and the character of the ventral surface. Some specimens have a typical trifid process which bends forward and is smaller relative to the size of the valves. We have illustrated the two most common types, one with a fairly flat ventral surface and with side lobes at less than a right angle to the central lobe (pl. 54, figs. 2–5), and one with a median sulcus on the central lobe and side lobes essentially at a right angle to the central lobe (pl. 54, figs. 6–8). Each of these specimens consists only of the dorsal valve and we have not assigned either to a described species. It is possible that further investigation may make it possible to define species of this genus, partly at least, on the character of the process.

Genus MARGINIRUGUS Sutton, 1938
Plate 54, figure 1

A complete reversal of the general structure of the cardinal process is exhibited by

the genus *Marginirugus*. In all other forms studied, the process extends either straight out from the valve at the hingeline or at an angle, or curves toward the dorsal side. In *Marginirugus* it begins on the medium septum below the hingeline, extends ventrally into the visceral cavity, and does not project much beyond the level of the hingeline. This type of development suggests a small beak area in the ventral valve.

The process is very strongly built with the ventral surface sloping back and the posterior end about even with the hingeline. The posterior surface of the process of *Marginirugus* is comparable in part to the dorsal surface of the process of other Productidae. The lobate character is not so well developed as strength seems to have dominated the design of the structure. There is a lack of the strongly developed marginal ridges common to many other genera. The posterior surface of the process is divided by a sulcus which forms two lobes that are separated on the ventral side but converge toward the dorsal side and produce a V-shaped end or posterior surface which is striated like the dorsal side of other forms. From the junction of the two lobes a ridge, almost at right angles to the lobes, continues on the dorsal face and projects at the hingeline in the form of a hook similar to that in *Dictyoclostus*. The function of this hook was probably for clasping the beak of the pedicle valve.

Genus MARGINIFERA Waagen, 1884
Plate 53, figures 6–15

The cardinal process of *Marginifera* begins at the junction of the medium septum and the marginal ridges which form its base. These structures are highly variable among the different species. The processes of the different species also show some differences, but certain characteristics are true for the group as a whole. On some specimens the process is low on the hingeline, on others it is rather well extended.

From the ventral surface, the process in many specimens appears simple, but a few

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EXPLANATION OF PLATE 53

FIGS. *1–5*—Genus *Productella* Hall. (p. 324)

1, 2, Productella pyxidata (Hall), Mississippian, Louisiana limestone, Louisiana, Missouri, exterior and interior of two dorsal valves, ×2, U. I. E-1774.

3–5, Productella hallana Walcott, Devonian, Lime Creek shale, Hackberry Grove, Iowa. *3*, interior of dorsal valve, ×2; *4, 5*, exterior and interior views of same specimen, ×4, U. I. D-3975.

6–15—Genus *Marginifera* Waagen. (p. 326)

6, 7, Marginifera splendens (Norwood and Pratten); exterior and interior of dorsal valve of a specimen from the Lonsdale limestone, Pennsylvanian, Peoria County, Illinois, ×2, Illinois State Geological Survey collection, No. A, IV, 8; *8*, ventral view of cardinal process of same specimen, ×4.

9–12, Marginifera haydenensis (Girty), *9, 10*, exterior and interior of a dorsal valve from the Pumpkin Creek limestone, Pennsylvanian, ×2, Illinois State Geological Survey collection, No. A, VI, 8; *11, 12*, ventral and dorsal views of cardinal process of same specimen, ×4.

13–15, Marginifera splendens, 13, 14, exterior and interior of a dorsal valve from the Pennsylvanian of Sangamon County, Illinois, ×2; Illinois State Geological Survey collection No. A, VI, 4. *15*, ventral view of process of same specimen, ×4.

16–21—Genus *Linoproductus* Chao. (p. 327)

16–18, Linoproductus sp. from the Hanover limestone, Pennsylvanian, near Galesburg, Illinois; *16*, interior of dorsal valve. *17, 18*, ventral and dorsal views of process of same specimen, ×3; U. I. F-3994.

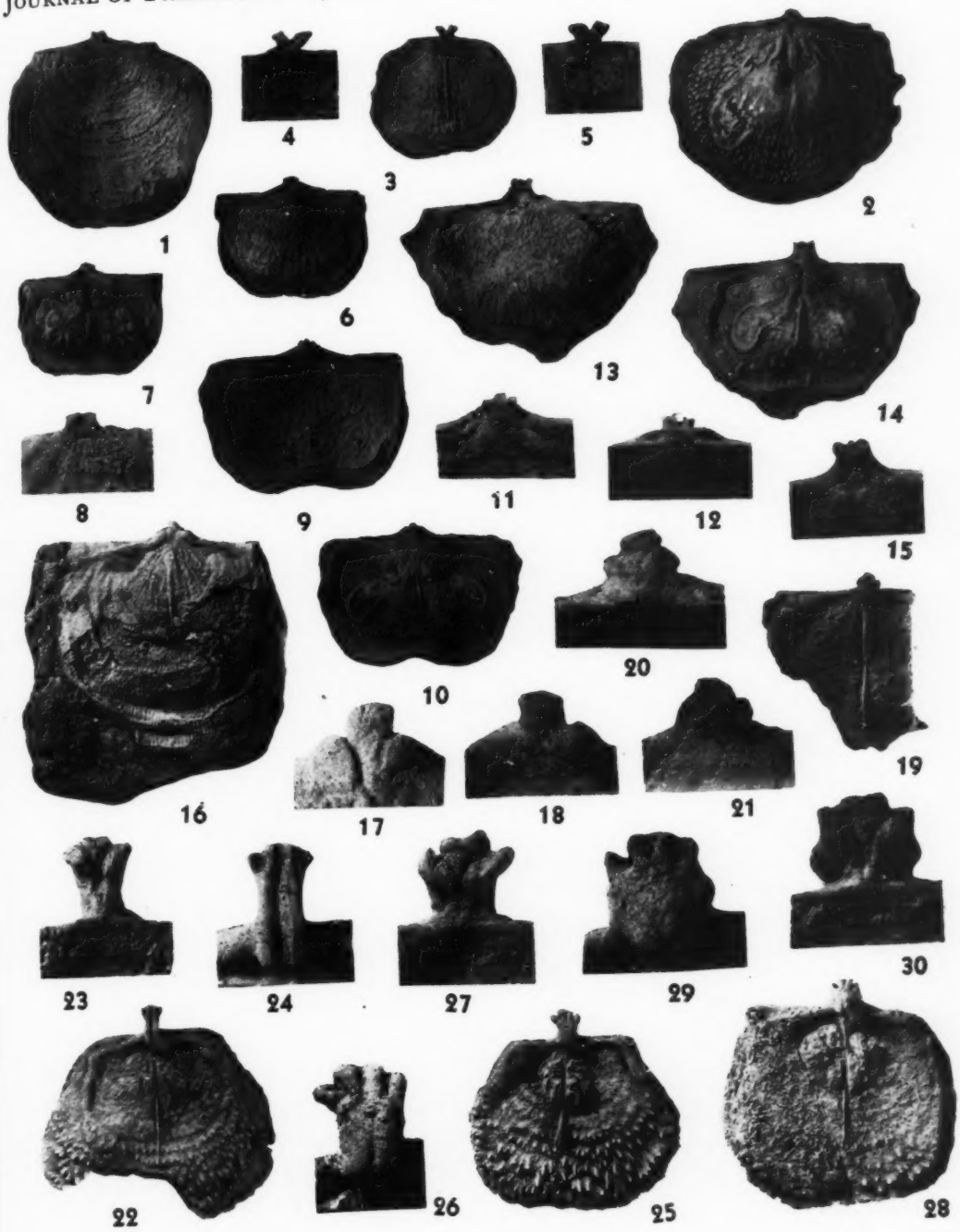
19–21, Linoproductus sp. from the shale over the Shoal Creek limestone, Pennsylvanian, Illinois State Geological Survey collection, B. I, 14; *19*, interior of dorsal valve; *20, 21*, dorsal and ventral views of cardinal process of same specimen, ×3.

22–30—Genus *Juresania* Fredericks. (p. 328)

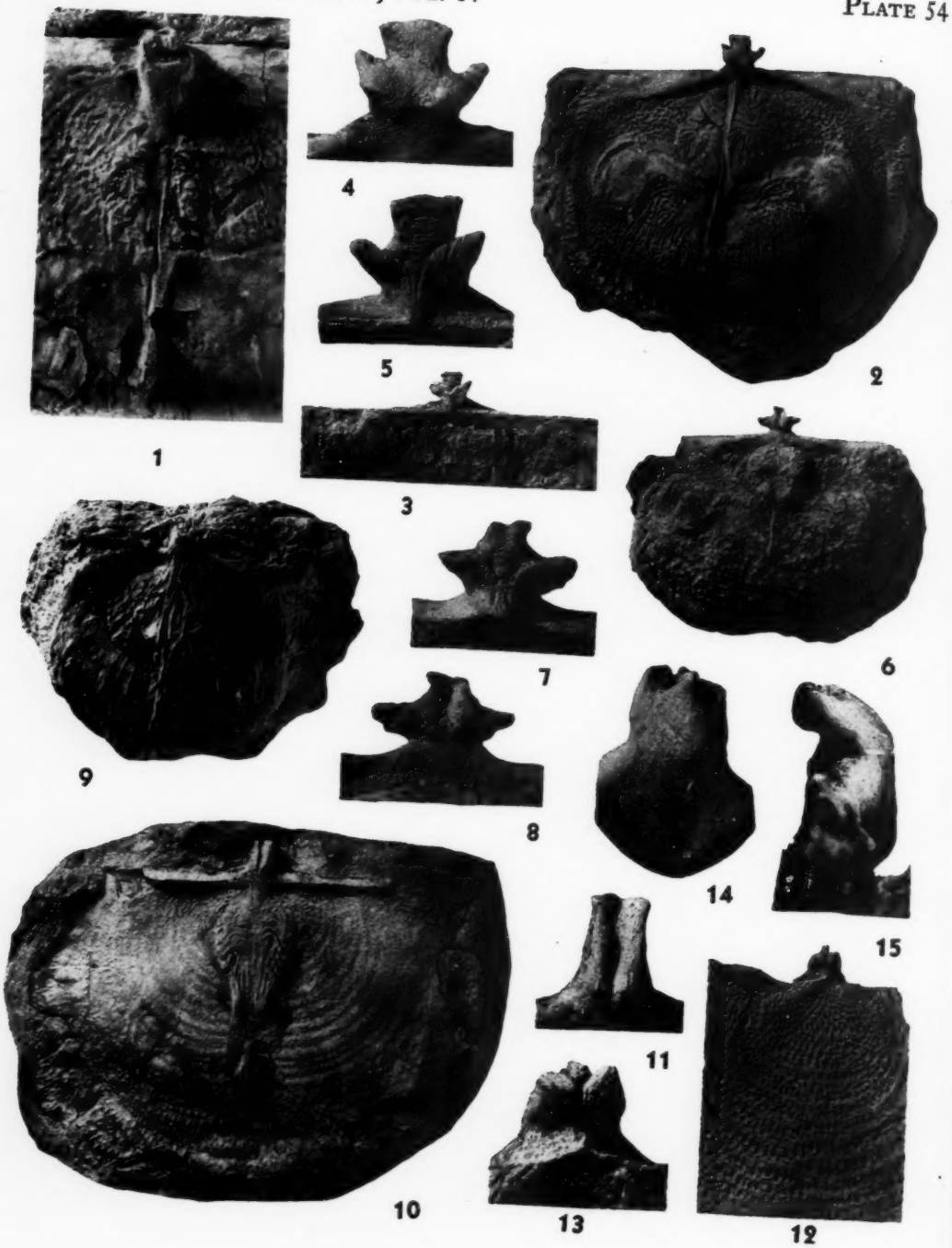
22–24, Juresania sp. from the shale over the Shoal Creek limestone, Pennsylvanian; Illinois State Geological Survey collection, C. I. 14; *22*, interior of dorsal valve; *23, 24*, dorsal and ventral views of cardinal process, ×3.

25–27, Juresania sp. same locality and formation as above; *25*, interior of dorsal valve; *26, 27*, ventral and dorsal views of cardinal process, ×3.

28–30, Juresania sp. from the Pennsylvanian, middle shale bed of the Farley, Federal Quarry, 2 miles west of Walcott, Kansas; Kansas Univ. Museum, No. 1728; *28*, interior of dorsal valve; *29, 30*, ventral and dorsal views of cardinal process, ×3.



Sutton and Summerson, Productidae



Sutton and Summerson, Productidae

have lip-like projections surrounding the sulci. There are two sulci which spread back from the dorsal surface and widen toward the ventral side with a loop-like outline on either side of the central lobe. These depressions form a trifid process which is characteristic of the genus. The center lobe has a slight furrow down the center of the distal end. This genus is unique in that the sulci are curved rather than deep and straight. In all other Productidae the separation of the lobes is affected by straight simple clefts or sulci, producing flat surfaces on the sides of the lobes.

A different structure in this group is a second process paralleling the hingeline and dorsal to the cardinal process. It rises from a constriction of the marginal ridges which extend around the process to the dorsal side. Along the hingeline this ridge extends only on the dorsal side of the process and forms a longitudinal sulcus between the ridge and process in which the two transverse depressions join. The ridge is not a dorsal projection such as occurs in some genera, but projects upward from the hinge area. The attitude of the valves in their normal position probably gave this projection the same function as the hook noted in other forms.

It should be noted that the group commonly referred to as *Marginifera* is considered by some workers to be polyphyletic. J. M. Weller (personal communication) believes that there are several genera represented among the forms called *Marginifera*, and is studying the group in an effort to separate it into the various genera which have been included in this one genus. The characters given are those for the group as a whole, with attention called to some of the variations which may prove to be valuable if this group is separated into more than one genus.

Genus Linoproductus Chao, 1927
Plate 53, figures 16–21

The cardinal process of *Linoproductus* is trifid and smaller in relation to the size of the shell than the process of *Dictyoclostus*. It is developed from an enlargement of the medium septum and the lateral ridges. In one of the specimens illustrated the lateral lobes on the ventral side of the process seem to be swellings of the marginal ridges rather than parts of the cardinal process, but they assume more normal shape on the dorsal side. Dorsally, each lobe slopes backward and the ventral side is almost straight, differing in this respect from *Dictyoclostus*.

The middle lobe of the process of some specimens contains a furrow that is deep and suggests a tetralobate shape. The side lobes are angled dorsally producing a V-shaped appearance of the dorsal face. The central lobe projects high above the side lobes, which do not extend outward from it at large angles, thus differing again from *Dictyoclostus*. The dorsal surface of the process has the transverse striations common to the structure in all genera of Productidae.

Genus Echinoconchus Weller, 1914
Plate 54, figures 10–15

The cardinal process of *Echinoconchus* is distinctly bilobed from its point of origin at the junction of the heavy marginal ridges

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Explanation of Plate 54

Figs. *1*—Genus *Marginirugus* Sutton; interior of a portion of the dorsal valve of the holotype of *M. magnus* (Meek and Worthen), the genotype, U. I. X-81. (p. 325)

2–8—Genus *Dictyoclostus* Muir-Wood. (p. 325)

2, 3, Dictyoclostus sp. Interior and portion of exterior of a dorsal valve from the Pennsylvanian; University of Iowa collection; *4, 5*, ventral and dorsal views of the cardinal process of same specimen, ×3; *6*, interior of another dorsal valve, U. I. F-3997; *7, 8*, dorsal and ventral views of process of same specimen, ×3.

9—Genus *Productus* Sowerby. Interior of a specimen of *P. cestriensis* Worthen from the Chester of western Kentucky, U. I. E-2345, ×2. (p. 325)

10–15—Genus *Echinoconchus* Weller. (p. 327)

10, 11, Echinoconchus semipunctatus var. knighti (?); *10*, interior of a dorsal valve from the Pennsylvanian of Pike County, Illinois; Illinois State Geological Survey collection, C, II, 14; *11*, ventral view of the process of the same specimen, ×3; *12–15, Echinoconchus semipunctatus* (Shepard); *12*, exterior of a dorsal valve from the Pennsylvanian of Clark County, Illinois, Illinois State Geological Survey collection, B, III, 5; *13–15*, dorsal, ventral, and lateral views of the cardinal process of the same specimen, ×3.

and the medium septum. The base of the process is rather distinctive in its appearance. Two prominent elliptical lobes are developed at the lower ventral side of the structure. These lobes are usually proportional to the size of the specimens which are often large. The posterior surface of each lobe is gently curved toward the dorsal side of the valve. The process possesses a slight constriction in about the plane of the dorsal valve and projects dorsally several millimeters beyond this point. Toward the dorsal side, however, the structure widens and becomes trilobed.

The sulcus that divides the two elliptical lobes continues to the end of the center lobe. At the extremity of the center lobe there is a slight spreading on each side facilitating the attachment of the muscles. The two lateral lobes are dorsal to and at the sides of the center lobe and are continuations of the lower portions of the eiliptical lobes. The inner extremities of the lobes have slightly hooked apophyses for muscle attachment. From the dorsal side of the valve the side lobes join at an angle below the center lobe. There is a variation in the development of the trilobed character on the dorsal side of the process. Some processes have a well defined trilobed shape with the side lobes far apart, others have the division less distinct and the side lobes close to the central lobe.

Genus JURESANIA Fredericks, 1928
Plate 53, figures 22–30

The cardinal process of *Juresania* is similar to that of *Echinoconchus*. It rises from the junction of the marginal ridges and the medium septum at the hingeline. The lower portion of the process is bifid with rounded lobes like those of *Echinoconchus*. The process, which is straight rather than curved, is set back from the valve and tilted toward the dorsal side. At the distal extremity of the process there is a tetralobed development, much more prominent on the ventral than on the dorsal surface, which is characteristic of the genus. In most specimens the central sulcus does not extend across the end of the process to the dorsal side so that in dorsal view the process exhibits a trilobate rather than a tetralobate appearance. The side lobes are much the same as in *Echinoconchus*, and have the center lobe separated into two lobes by a deep sulcus on the ventral side. The spread of these lobes varies greatly. Some specimens show a wide spread with a definite development of all four lobes while in others the lobes are tightly pressed together and show only a slight development of the sulcus in the center lobe. There is a variation at the base of the process also. Some processes continue smoothly from the medium septum but on most specimens they project from the hinge-line area to form a pair of ventral projections. The dorsal side of the process is striated horizontally and the lobes have apophyses at the extremities which curve into hook-like forms to facilitate the attachment of the muscles.

Variations of the process among the different specimens that have been studied are so pronounced that it would seem probable that the process might serve as a basis of specific definition. Three of the most pronounced varieties have been illustrated. If it were not possible to see the internal structures, these specimens, especially two of them (pl. 54, figs. 22, 25), might be assigned to the same species. None of these specimens would seem to be exactly like *Juresania nebrascensis* (Owen) as that species has been interpreted by Dunbar and Condra (1932, pp. 195–198; pl. 22, figs. 3a, 3b). The one illustrated (pl. 54, fig. 28), from the middle shale of the Farley (Pennsylvanian) which R. C. Moore included in the Kansas City group in 1931, seems closest to *J. symmetrica* (McChesney). According to Dunbar and Condra (1932, p. 200) this species is characteristic of the Kansas City group. The type of process illustrated by figure 22 is quite distinct from the other two. The description of the cardinal process of *J. ovalis* Dunbar and Condra (1932, p. 201) suggests that it may be quite similar to this form.

Genus WAAGENOCHONCUS Chao, 1927

Chao (1927, p. 93) described the process of this genus as follows:

> The cardinal process is large and strong projecting far beyond the hingeline. It is divided by a median sulcus into two lobes, each of which is further divided terminally. The lobes are continued toward the front into two forward projecting pustules.

Genus PUSTULA Thomas, 1914

According to Thomas (1914, p. 311, pl. 17, fig. 23):

> The interior of the brachial valve shows a high cardinal process which is bilobed when viewed from the inside of the valve and apparently is produced laterally on both sides in a prominent ridge which is continued to the postero-lateral portion of the valve, here it merges in the general surface of the shell.

Genus OVERTONIA Thomas, 1914

Thomas (1914, p. 336, pl. 20, fig. 12) characterized the cardinal process of this genus as follows:

> The cardinal process is very prominent and high and extends, as seen from the inner side, in two strong ridges separated by a deep groove, reaching a height of 3 mm. above the hinge margin in the figured specimen from the Neilson collection. The ridges terminate posteriorly in a prominent lobe which appears quadrilobate when looked at from the posterior end with the line of vision parallel to the plane of the valve.

The illustration indicates a bilobed appearance when viewed from the interior or ventral surface of the valve.

Other Genera

The internal features of the dorsal valve of the following genera have not been well described: *Aulosteges* Helmarson, 1887; *Sacchinella* Gammellaro, 1896; *Avonia* Thomas, 1914; *Buxtonia* Thomas, 1914; *Striatifera* Chao, 1927; *Horridonia* Chao, 1927; *Cancrinella* Fredericks, 1928; *Krotovia* Fredericks, 1928; *Marginicinctus* Sutton, 1938.

PHYLOGENETIC SIGNIFICANCE AND TAXONOMIC VALUE

This study of the cardinal process of the previously described genera of Productidae has afforded some evidence on the evolution of a portion of the family. In the early forms of *Productella*, the process is a simple bifid type whose structural growth is recorded in the simple layering of the material of the shell. The dorsal side of all processes studied shows a series of transverse and longitudinal striations, which were formed by the addition of layer upon layer of shell material on the inner surface, because the growth was inward. As the animal grew, the process increased in size and the mature forms developed complexities characteristic of their respective genera. In fragments which exhibit cross sections of the process, there is shown the development from a simple knoblike form to the complex mature specimen.

The bifid process of *Productella* is the simplest of the forms studied, and is quite similar to the process of a Devonian species of *Stropheodonta*. The cardinal process of the latter genus is like that of *Productella* in that it is bifid and tends to be flattened with diverging lobes like that of *Productella hallana* of the Devonian.

It would seem from the general structure of the process that, following the development of *Productella*, the genus *Productus* evolved with a typical trifid process. In *Productus* the process has lobes that extend dorsally from the base of the process at right angles to the plane of the valve. Further development of the cardinal process was along two main lines. One type is characterized by a trifid process as in *Dictyoclostus*. The other is primarily a bifid type that projects forward and develops into a trilobed or a tetralobed form as in *Echinoconchus* and *Juresania*.

The development of the trilobed type, as exemplified by *Dictyoclostus*, is suggested by the increased development of the sulci of the genus *Productus*. With the continuance of the lateral sulci ventrally and the widening of the angle between the lobes the more specialized trifid process of *Dictyoclostus* evolved.

The bifid type, characterized by *Echinoconchus*, may have been developed by the ventral increase of the median sulcus causing the bilobed character of the ventral portion. Dorsally *Echinoconchus* developed a trifid process. Extension of the median sulcus toward the dorsal side divided the center lobe and this groove, together with the side sulci of the trilobed process produced the tetralobed forms. The tetralobed process is especially well developed in *Juresania*.

From the branch leading to *Dictyoclostus* a divergent line of development resulted in the characteristic process of *Marginirugus*. This began originally as a trifid process, but in specialization for strength the center lobe

was sacrificed and the process became bilobed. The structure of *Marginirugus* suggests that the beak was shallow. The process, instead of extending much beyond the hingeline, was developed ventrally into the visceral cavity and its base was extended down the dorsal valve. The size of the shell demanded this extreme in development in order to compensate for the strain caused by the weight of the valves in opening.

From the same stem but branching off before *Dictyclostus*, came *Linoproductus*. This form is little more than a slightly specialized *Productus*. Both have similar internal structures except for the diaphragm around the visceral disk of the dorsal valve of *Productus*. This cardinal process is definitely trifid on the ventral side as the continuation of the sulci resulted in the formation of the side lobes.

In the genus *Marginifera* there is a variety of forms having a trilobed process. All are of a distinct type, however, and are distinguishable from *Dictyoclostus* and other trifid forms. The particular type of sulci in the top surface of the process is unique for this group. A new development of the marginal ridge, dorsal to the process, is also characteristic of certain species of *Marginifera* s.l. This ridge seems to have developed from the marginal ridges and is not a part of the cardinal process.

SUMMARY

In the discussion of the development of the cardinal process the characters distinctive of the different genera have been pointed out. It has been found that this structure is a valuable criterion for determining the phylogeny of the group. The phylogeny as determined by the cardinal process is comparable to that developed on the external characters by Sutton (1938, p. 545). We are of the opinion that the cardinal process can serve as a generic characteristic but that variations between individuals are not yet correlated well enough with other characters to make this structure in itself a reliable specific determinant. The use of the structure for taxonomic purposes should therefore be limited to the definition of genera.

The study of the family is of necessity incomplete. Lists of the genera unavailable to us for study are given and references are included for those that have been described. Some forms have no known specimens that show the structures studied and have been listed without comment. We feel that the references to these genera in the literature are so brief that it is impractical to discuss or try to fit them into the history of the development of the family.

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UPPER CRETACEOUS FORAMINIFERA FROM NORTHWESTERN PERU

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ABSTRACT—The Mal Paso shale, known only in subsurface in the Department of Piura, Peru, reaches a maximum thickness of over 6500 feet. The upper half of the formation carries a distinctive predominantly arenaceous foraminiferal fauna, which is correlated with parts of the Tamesi formation of Mexico, the Tarouba formation of Trinidad, the Santa Anita formation of Venezuela, and the Mito Juan and "Orocue" formations of Colombia. Below the Mal Paso shale are conglomerates, underlain possibly unconformably by shales of the Copa Sombrero formation. In the vicinity of Negritos, no sedimentary break separates the Mal Paso from overlying basal Tertiary shales. A total of 52 species and varieties of Foraminifera are described from the Mal Paso shale, 15 of which are new.

INTRODUCTION

LITTLE is known of the Cretaceous rocks and faunas which occur in the northwestern part of Peru. Published papers[1] are largely of a reconnaissance nature, and none deal with the occurrence or correlation of foraminiferal assemblages. It therefore is of particular importance in regional geology and stratigraphy to record from this area an uppermost Cretaceous foraminiferal fauna from a formation apparently continuous with strata of earliest Tertiary age.

The area discussed in this report is located in the Department of Piura, Peru, South America, extending between Latitudes 4° 15′ to 4° 45′ South, and Longitudes 80° 45′ to 81° 20′ West (text-fig. 1). Within this region, Cretaceous outcrops are found along the western flank of the Amotape Mountains, in the down-dropped block north of the Pananga fault system, and to the east of the southern extension of the Amotape Mountains. The subsurface occurrence of Cretaceous strata, which has been studied in detail, extends from the Amotape Mountains at La Brea to the vicinity of Negritos on the sea coast.

Study of the uppermost Cretaceous Foraminifera of northwestern Peru has been in progress since early in 1937, as the exigencies of economic work and the press of other activities have permitted. In addition, four weeks in March and April 1940, were spent at the Cushman Laboratory for Foraminiferal Research, in an intensive study of the Mal Paso fauna. These studies were based upon the examination of samples from more than 145 wells which have reached strata of Cretaceous age, one of which is believed to have completely penetrated the Cretaceous section. No revision of the stratigraphy of the Cretaceous, as described from outcrops in the field, has been attempted, pending the completion of field studies now in progress. The stratigraphic nomenclature accepted is that of Olsson (1934), except in the case of the Mal Paso shale.

Although this paper is primarily concerned with regional stratigraphy, some taxonomic and paleobiological conclusions are included. Attention is called to *Orthokarstenia* Dietrich, 1934, a synonym of *Siphogenerinoides* Cushman, 1927. *Bolivinopsis* Yakovlev, 1891, which eventually must replace either *Spiroplectammina* Cushman, 1927, or *Spiroplectoides* Cushman, 1927, is rejected as a *nomen dubium* until topotype specimens of the genotype may be studied in detail. *Spiroplectoides* Cushman is revived to fill the vacancy left by *Bolivinopsis*. Slight modifications of Cushman's derivation of the genus *Pseudoglandulina* are made, but his hypothesis of a lagenid origin of the genus is supported by the ontogeny of specimens from northwestern Peru.

Disposition of type specimens.—All specimens illustrated in this paper, with the exception of the hypotype of *Pelosina complanata* Franke, have been deposited in the type collection of the Cushman Laboratory for Foraminiferal Research, Sharon, Massa-

[1] Olsson (1934) gives a summary of reports on the Cretaceous geology and paleontology of the region.

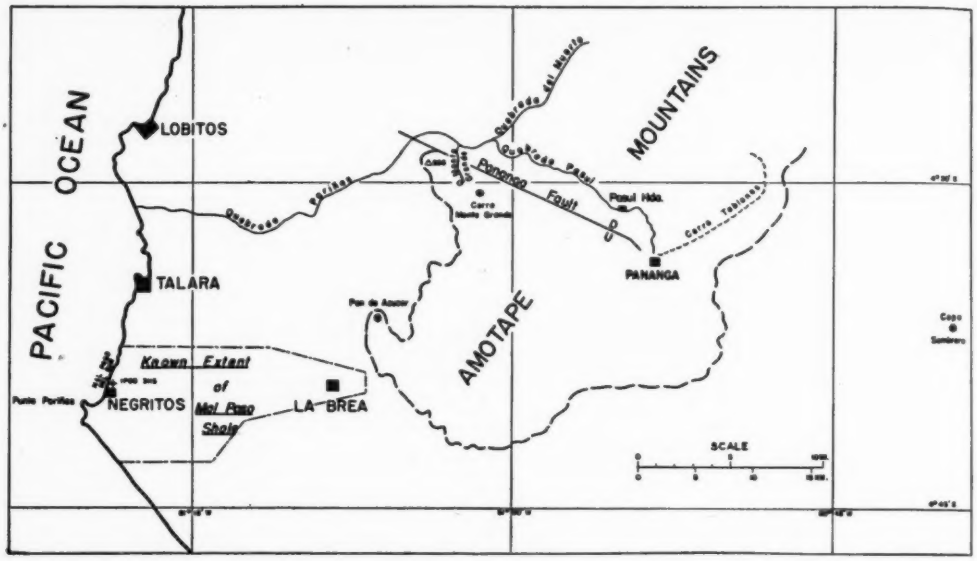

FIG. 1—Map of a portion of northwestern Peru, showing the subsurface occurrence of uppermost Cretaceous in the area.

chusetts. Where possible, duplicate material will be placed in the collection of the International Petroleum Company, Limited, Negritos, Peru, the paleontological type collection of Stanford University, California, and in my own personal collection.

Acknowledgments.—The following report has been made possible to a great extent through the courtesy of J. A. Cushman, who graciously allowed me the facilities of his laboratory during four weeks in March and April, 1940. Without the advantages of access to his card catalogue, type collection, library, and a typescript dealing with the Upper Cretaceous of North America, this study could not have been completed. It is to be stressed, however, that the identifications and conclusions embodied in the following pages are entirely my own, and are not necessarily in agreement with the views of any other person.

For the privilege of an extension of leave, to complete the study of the Mal Paso fauna, I am indebted to the officers and Directors of the International Petroleum Company, Limited, who have generously allowed the paper to be published in its present form.

The illustrations of Foraminifera were drawn by Ann Shepard Green, of Sharon, Massachusetts.

MAL PASO SHALE

The name Mal Paso was proposed by Wiedey and Frizzell (1940, p. 528) in a very brief review of the Eocene stratigraphy of northwestern Peru, for the predominantly shaly sequence encountered in wells below the basal Tertiary "main sand" of the Negritos shale. The Eocene stratigraphic column employed in this paper is that of Wiedey and Frizzell (1940):

Verdun group:
- Pajaro Bobo shale
- Charanal formation
- Chira shale
- Verdun formation

Talara group:
- Pozo shale
- Talara sandstone
- Talara shale
- Lomitos sandstone

Negritos group:
- Chacra shale
- Parinas sandstone
- Keswick formation
- Salina formation
- Negritos shale

The formation was named from one of the numerous "bad passages" of rocky coast,

roughly a quarter of a mile to the north of the town of Negritos, known locally as Mal Paso del Sur. The type section, not indicated in the original proposal, is here designated as that penetrated by I.P.Co. well no. 3115.[2] Included with the formation are the lower 1000 feet of Bosworth's "shales unexposed" of the Negritos formation (Bosworth, 1922, p. 24), and the lower 3500 feet of the Negritos formation of Iddings and Olsson (1928, p. 11).

In the type section, the formation is composed predominantly of shales, with occasional sandy zones from 10 to 150 feet thick including moderately thin interbedded shales. Lithologically, the shales are medium hard, dark gray to gray-black, massive or coarsely laminated, typically noncalcareous, commonly fractured and slickensided. The formation has been completely penetrated only in I.P.Co. well 3115, where a corrected thickness of approximately 6665 feet was found, grading below into sandstones and conglomerates and continuing above into basal Tertiary shale. The fossiliferous portion of the Mal Paso shale in this well is restricted roughly to the upper half of the formation. On the basis of cores examined, this represents a minimum true thickness of around 3325 feet for the fossiliferous upper part, with a possible maximum of slightly more than 4000 feet.

As known in wells, the Mal Paso shale has a very limited areal extent, being confined to a roughly triangular area some seven miles wide at the coast and extending 15 miles inland. This limited distribution conforms with a structural upwarp extending in a general way from the vicinity of the town of Negritos eastward to La Brea, which has brought to the surface older Tertiary strata. It is probable, however, that the actual extent of the formation is considerably greater, and that it occurs in other areas in the coastal belt at depths which have not yet been reached by drilling.

The formation has been encountered at depths as shallow as 100 feet, but elsewhere it has not been reached by wells more than 7000 feet deep. Because of the intense and complex faulting involved in the area, the true stratigraphic relationship of the Mal Paso shale with overlying beds has been difficult to determine. The formation, at various places, is overlain by Tertiary strata ranging from the Negritos shale to the Verdun formation, generally with evidence of faulted contacts. Where the upper boundary of the Mal Paso shale appears to be undisturbed, however, it is overlain by lithologically similar shale, usually without foraminifera, referred to the Negritos shale of Tertiary age.

The Upper Cretaceous rather than Tertiary age of the Mal Paso shale is demonstrated by the following species, which others believed not to occur in strata of Tertiary age: *Marssonella oxycona* (Reuss), *Pseudoclavulina clavata* (Cushman), *Spiroplectammina grzybowskii* n.sp., and *Pelosina scruposum* (Berthelin). Stratigraphic confirmation of this age determination is indicated by the position of the formation in apparent conformity below the Negritos shale.

An attempt at final correlation of the Mal Paso shale with other formations described from northwestern Peru, would be premature in the absence of more detailed information regarding the Cretaceous stratigraphy of the region. It is believed, however, that unfossiliferous lower part of the Mal Paso shale is equivalent to the "*Clavulina* shales" and the overlying Monte Grande formation of Olsson (1934). This interpretation is based upon local and regional stratigraphic succession, and upon the foraminiferal fauna obtained from samples of the "*Clavulina* shales."

SUBSURFACE CRETACEOUS SECTION AT NEGRITOS

The Cretaceous section has been completely penetrated in a single well, drilled on the coast near the town of Negritos. I.P.Co. well 3115, in Square Mile 2-N-2, 1767 feet north, 3357 feet east,[3] was completed in September, 1941, at a final depth of 9781 feet, and was abandoned as a dry hole. This well started in Negritos shale and encountered the "main sand" between depths of approximately 425 to 490 feet. At

[2] I.P.Co. = International Petroleum Company, Limited; the abbreviation is used throughout the present paper.

[3] The system of locating wells used in this paper is explained on page 335.

530 feet, the uppermost Cretaceous was identified, apparently continuous with the lowermost Tertiary shale. The Cretaceous section extended to a depth of 9472 feet, where partially metamorphosed unfossiliferous sedimentary rocks of probable Paleozoic age were encountered. Three formations of Cretaceous age are recognized in this well, as follows:

Well Depths	Formation
530–7430	Mal Paso shale
7430–7809	"Middle conglomerates"
7809–9472	Copa Sombrero formation

A series of sandstones and conglomerates was encountered below the Mal Paso shale, in apparent conformity. A core six inches long was composed of very hard gray conglomerate, moderately well sorted, with many moderately well rounded quartzitic pebbles one to one and a half inches in diameter, and with occasional angular fragments of Copa Sombrero shale reaching a maximum diameter of four inches. The matrix consisted of fine sand and shaly material, calcareous and very firmly cemented. These sandstones and conglomerates are referred to the "Middle conglomerates" of the Amotape Mountains (Olsson, 1934, pp. 11, 15, fig. 2) because of their stratigraphic position between the presumed Copa Sombrero formation and shales of the uppermost Cretaceous.

Beneath the "Middle conglomerates" this well penetrated approximately 1605 feet (corrected for dip) of very hard, dense, noncalcareous, massive to laminated, black shale, partly fractured and slickensided, with rare calcite veinlets, and with included pebbles near the top. Unconformity with the overlying sandstones and conglomerates is postulated because of the sharp change in lithology from the Mal Paso shale, and because fragments of the Copa Sombrero shale occur in the overlying conglomerate. These strata are referred to the Copa Sombrero formation on the basis of lithologic similarity to exposures in the Amotape Mountains, and because of their stratigraphic position. The Cretaceous age of the unit is demonstrated conclusively by the foraminifera contained in drill cuttings and cores, in particular sparse to abundant specimens of the genus *Siphogenerinoides*.

CORRELATION OF THE MAL PASO SHALE

The fossiliferous upper half of the Mal Paso shale, on the basis of its fauna, is believed to be younger than the Navarro (Cretaceous) and older than the basal Tertiary Midway of Texas, and not represented in the Gulf Coast section of the United States. Because this position is occupied by the Tamesí formation[4] of Mexico (Velasco shale of authors), a general correlation with that unit is indicated. This conclusion has been substantiated by comparisons of the Mal Paso fossils with faunas from the Tamesi formation, and the upper part of the Tarouba formation (Lizard Springs beds) of Trinidad. The unfossiliferous lower part of the Mal Paso shale cannot be correlated at the present time. Probably, however, its relationships eventually may be determined on the basis of detailed studies of the microfauna of the presumably equivalent "*Clavulina* shales" (Olsson, 1934).

In Venezuela, an equivalent of the fossiliferous upper part of the Mal Paso shale is found 500–1100 feet above the base of the Caratas member of the Santa Anita formation (Hedberg, 1937, pp. 1996–2000). Probably the lower part of the Caratas member, and perhaps the underlying San Juan sandstone member, are represented by the unfossiliferous lower part of the Mal Paso shale. The equivalent in northern Colombia of the fossiliferous part of the Mal Paso shale appears to be the Mito Juan formation and the lowermost part of the "Orocue" formation (Cushman and Hedberg, 1941). If so the unfossiliferous lower portion of the Mal Paso shale possibly is equivalent to the Colón shale.

CRETACEOUS-TERTIARY BOUNDARY

Conditions during latest Cretaceous and earliest Tertiary time in South America, have been summarized by Hedberg (1937, pp. 1998–1999) as follows:

"Throughout much of the deeper portion of the Andean geosyncline of northern South America there was no break in deposition between Cretaceous and Tertiary time, and the interval near the boundary between those periods is represented in other regions

[4] A detailed discussion of the Tamesí formation is given by Muir (1936, pp. 76–92).

by formations approximately equivalent to the Santa Anita formation. In western Venezuela the time equivalents of the Santa Anita formation are the Mito Juan (Upper Cretaceous) formation and the Río de Oro and Guasare formations (Upper Cretaceous-Paleocene). In Colombia the Santa Anita formation is probably equivalent to the uppermost Umir and a part of the Lisama formation. In Trinidad, the upper part of the Tarouba formation (Lizard Springs shale, Hobson's clay, 'soft argiline') is to be correlated with the Caratas member of the Santa Anita formation. The *Venericardia planicosta* horizon of Cerro Corazon, which probably lies within or just above the upper part of the Caratas member, can be definitely correlated with similar *Venericardia* limestones in the Marac formation of Trinidad, with the Soldado formation of Soldado Rock (between Venezuela and Trinidad), with the Toas Island limestone and the Guasare limestone of western Venezuela, with *Venericardia* limestones in northern Colombia, and perhaps with the Parinas formation of Peru."

A similar depositional sequence is found in the vicinity of Negritos. Beginning with the Upper Cretaceous "Middle conglomerates," extending upward through the Mal Paso shale, the basal Tertiary Negritos shale, and into the Salina formation, no depositional hiatus is recognized and deposition appears to have been continuous from late Cretaceous at least into early Eocene time. Paleocene strata have not been recognized in northwestern Peru,[5] although they must be represented by at least part of the Negritos shale. The latter, which constitutes the lower part of the *Mesalia negritosensis* zone (*Turritella* series of Bosworth, 1922, p. 23), is almost entirely lacking in megafossils and contains only sporadic and sparse foraminiferal assemblages, chiefly characterized by poorly preserved specimens of the genera *Anomalina* and *Robulus*. It therefore has not yet been correlated on any basis other than stratigraphic evidence.

[5] It is to be stressed that *Venericardia parinensis* Olsson does not occur within any probable limits of the Paleocene in northwestern Peru (cf. Rutsch, Ecl. geol. Helv., vol. 29, no. 1, 1936, pp. 152–186, quoted by Hedberg, 1937, p. 1998), and that the Parinas sandstone is of approximately middle Eocene age.

The geological history of the Amotape Mountain region may be different from that of the Negritos region (cf. Olsson, 1932, especially fig. 3). At the present time, the Mal Paso fauna is not known from outcropping rocks, nor are chronologically equivalent strata recognized. Whether the absence of the Mal Paso microfauna in outcrop resulted from erosion or nondeposition, however, is not known.

LOCATION OF WELLS

The wells from which figured specimens have been taken were drilled by the International Petroleum Company, Limited, and are located in the Department of Piura, Peru, South America. The following locations are based upon a grid for the area (Bosworth, 1922, folders I and II, opposite pages 7 and 25), using square miles north and south and to the east of Parinas Point (Square mile 1-S-6, for example, is from 0–1 south and 5–6 east on Bosworth's map). In the following tabulation, the coordinates are measured from the southwestern corners of the various square miles.

I.P.Co. Well	Square Mile	Coordinates (Feet)
1755	1-S-6	3050 north, 590 east
1832	1-N-5	1250 north, 4870 east
2000	1-N-7	1950 north, 450 east
2174	3-N-8	1333 north, 3820 east
2841	2-N-4	2895 north, 527 east
3013	2-N-8	3968 north, 1600 east
3040	3-N-10	985 north, 2498 east

Additional data, acquired since the present paper was accepted for publication, demand the elimination of six species from the original Mal Paso list. Well 2616, in square mile 1-N-15, 2593 feet north, 3380 feet east, penetrated the "*Clavulina* shale" rather than Mal Paso strata. The following species are affected: *Siphogenerinoides cretacea*, *S. clarki*, *Bulimina reussi*, *Neobulimina* sp. aff. *N. canadensis*, *Rotalia* sp. cf. *R. beccariiformis*, and *Globigerina* sp. cf. *G. cretacea*.

SYSTEMATIC DESCRIPTIONS

Family Rhizamminidae
Genus Bathysiphon M. Sars, 1872
Bathysiphon carapitanus Hedberg
Plate 55, figure 1

Bathysiphon carapitanus Hedberg, *1937*, Jour. Paleontology, vol. 11, p. 665, pl. 90, fig. 1.

Test a collapsed tube, large, tapering very gradually, with occasional weak constrictions; wall thick, composed of very finely crystalline quartz (apparently recrystallized amorphous silica), with sparse sponge spicules visible; end of tube presumably forming aperture; dark gray in color, with vitreous to sugary texture.

Dimensions of hypotype (broken specimen), from I.P.Co. well 1755, 2110 feet depth: height, 2.04 mm.; width, 0.96 mm.; thickness, 0.46 mm.

The name *Bathysiphon carapitanus* is applied to large, robust, vitreous forms of the genus, moderately common in the Mal Paso shale. The species is abundant in parts of the Talara and Verdun formations (Eocene) of northwestern Peru, where specimens occur with diameters as great as several millimeters and lengths to several centimeters. Specimens from the Mal Paso shale have been compared with the holotype of the species, and are considered to agree in every respect.

The correctness of referring to the genus *Bathysiphon* these forms, first reported from Peru by W. Berry (1928, p. 405) as "fleshy algae," is beyond dispute. Examples from the Talara sandstone have been sectioned, and show the matting of sponge spicules which Brady (1884, pl. 26, figs. 17–20) figured for the genotype of *Bathysiphon*. Moreover, the gradually tapering tube and constrictions are peculiarly characteristic of the genus.

H. N. Coryell[6] has compared a specimen of *B. carapitanus* from the Talara formation with the holotype of *Kalamopsis dubia* White (1927, p. 185, pl. 27, fig. 3) from the Tamesi formation of Mexico, a species which, from the figure, is possibly identical with the Peruvian form. Coryell's summarized comparisons, which follow, show that the Mexican species is distinct and correctly referred to the genus *Kalamopsis* de Folin.

"*Kalamopsis dubia* White: These specimens are slender and frail, and apparently chambered.

"*Bathysiphon carapitanus* Hedberg: The specimens seem to be fragments of sturdy tubes."

[6] Personal letter, December 5, 1940.

BATHYSIPHON TAURINENSIS Sacco
Plate 55, figure 2

Bathysiphon taurinensis SACCO, *1893*, Soc. géol. France Bull. ser. 3, vol. 21, p. 168, text-fig. 2. CUSHMAN, *1931*, Cushman Lab. Foram. Research Contr., vol. 7, pt. 4, p. 88, pl. 11, figs. 12, 13.

Test a collapsed tube, large, very gradually tapering, with occasional weak constrictions; wall thick, composed of very finely crystalline quartz (apparently recrystallized amorphous silica), covered with a very thin carbonaceous(?) surface coating; aperture apparently at end of tube; surface black.

Dimensions of hypotype (broken specimen), from I.P.Co. well 1755, 1950 feet depth: height, 1.62 mm.; width, 0.78 mm.; thickness, 0.44 mm.

Bathysiphon taurinensis is characterized by a black or blackish surface coating. In northwestern Peru, it has been identified in the Keswick and Talara formations of the Eocene, and is moderately common in the Mal Paso shale.

Family SACCAMMINIDAE
Subfamily PELOSININAE
Genus PELOSINA H. B. Brady, 1879
PELOSINA COMPLANATA Franke
Plate 55, figure 4

Pelosina complanata FRANKE, *1911*, K. preuss. geol. Landesanstalt Jahrb., vol. 32, pt. 2, p. 107, pl. 3, figs. 1a–b. CUSHMAN and JARVIS, *1932*, U. S. Nat. Mus. Proc., vol. 80, art. 14, p. 5, pl. 1, figs. 4, 6 (not fig. 5 = *P. scruposa* (Berth.)).

Saccammina scruposum (Berthelin). WHITE, *1928*, Jour. Paleontology, vol. 2, p. 183, pl. 27, fig. 5 (not of Berthelin, 1880).

Test a collapsed flask, large, unilocular, broadly ovate in outline, usually obliquely distorted, diameter more than twice height; wall moderately thick, smooth, finely granular to amorphous (apparently recrystallized amorphous silica); aperture simple, with short neck in complete specimens.

The figured specimen, from I.P.Co. well 1755, 2750 feet depth, was lost when the types were returned to Peru by mail.

These moderately common forms in the Mal Paso shale are very similar to the fine-grained tests occurring in the Tarouba formation of Trinidad, as shown by comparison of specimens, and agree well with Franke's description and figures. Apparently identical specimens occur in parts of the Talara and

Verdun formations (Eocene) of Peru. White has listed *P. complanata* from the Papagallos, Mendez, and Tamesí (Cretaceous) of Mexico, as *Saccammina scruposum* (Berthelin).

PELOSINA SCRUPOSA (Berthelin)
Plate 55, figure 3

Haplophragmium scruposum BERTHELIN, *1880*, Soc. géol. France Mém., ser. 3, vol. 1, no. 5, p. 21, pl. 1, fig. 1.
Pelosina complanata Franke (in part). CUSHMAN and JARVIS, *1932*, U. S. Nat. Mus. Proc., vol. 80, art. 14, p. 5, pl. 1, fig. 5 (not figs. 4 and 6, nor of Franke, 1911).

Test a collapsed flask, large, unilocular, usually obliquely distorted, diameter greater than height, subcircular in outline; wall moderately thick, rugose, composed of clear quartz particles and siliceous cement; aperture simple, terminal, with short neck in complete specimens.

Dimensions of hypotype, from I. P. Co. well 1755, 2250 feet depth: height, 0.69 mm.; diameter, 1.68 mm.

This species is more nearly circular than *P. complanata* and has a more rugose surface. It was described from the "Gault or Albian" stage of Montcley, France, and occurs in the Cretaceous of Trinidad. In northwestern Peru, *P. scruposa* occurs rarely in the Mal Paso shale and is not known from younger strata.

Cushman and Jarvis regarded this form as conspecific with *P. complanata*. If so, *P. complanata* would fall within the synonymy of *P. scruposa*. However, I am influenced by the local range of the two forms, as well as by apparent differences in morphology, in making a provisional separation.

Family LITUOLIDAE
Subfamily HAPLOPHRAGMIINAE
Genus HAPLOPHRAGMOIDES Cushman, 1910
HAPLOPHRAGMOIDES ATAHUALLPAI
Frizzell, n. sp.
Plate 55, figures 5a, b

Test planispiral, medium large, moderately thick, usually obliquely distorted, circular in outline; chambers low, broadly and evenly arched, well marked, typically 11 in the last whorl; sutures deeply impressed on umbilical wall of whorl, slightly incised across periphery; wall thick, composed of very fine quartz grains and siliceous matrix, exterior very finely granular to vitreous in texture; aperture not visible on specimens examined.

Dimensions of holotype, from I. P. Co. well 1755, 2550 feet depth: height, 0.62 mm.; thickness, 0.29 mm.

This common Mal Paso shale species is unlike any of the forms which have been available for comparison. The specific name is derived from that of the ruling Inca at the time of the conquest of Peru.

HAPLOPHRAGMOIDES ZARATEI
Frizzell, n. sp.
Plate 55, figures 6a, b

Test planispiral, large, moderately compressed, nearly circular in outline; chambers high, numerous, about 13 in last whorl; sutures indistinct, apparently flush with surface of wall; wall moderately thin, poorly cemented, composed of fine quartz grains, exterior granular; aperture not visible on specimens examined.

Dimensions of holotype, from I.P.Co. well 2174, 3180 feet depth: height, 1.20 mm.; thickness, 0.27 mm.

Haplophragmoides zaratei somewhat resembles *H. calcula* Cushman and Waters, from the Cretaceous of Texas, but is much larger. The species is moderately rare in the Mal Paso shale.

HAPLOPHRAGMOIDES sp. aff.
H. DEFORMIS (Andreae)
Plate 55, figures 7a, b

Haplophragmoides deformis (Andreae). GALLOWAY and MORREY, *1931*, Jour. Paleontology, vol. 5, p. 333, pl. 37, figs. 5a–b (probably not *Haplophragmium deforme* Andreae, *1884*, Abh. geol. Specialkarte, Elsass-Loth., vol. 2, pt. 3, p. 197, pl. 8, fig. 1, from the Alsatian "Oligocene").

A single fine grained, tumid specimen was encountered, with nine chambers in the last whorl. This form is similar to *H. atahuallpai*, but is distinguished by being completely involute. More material will be required before a definite identification can be made. Galloway and Morrey have figured a specimen from the possible Tamesi formation equivalent of Tabasco, Mexico, which appears to belong to the same species.

Dimensions of hypotype, from I.P.Co. well 1755, 1990 feet depth: height, 0.73 mm.; thickness, 0.44 mm.

Genus AMMOBACULITES Cushman, 1910
AMMOBACULITES AGGLUTINANS (d'Orbigny)
Plate 55, figure 8

Spirolina agglutinans D'ORBIGNY, *1846*, Foram. Foss. Vienne, p. 137, pl. 7, figs. 10–12.
?Ammobaculites agglutinans (d'Orbigny). FRANKE *1928*, Preuss. Geol. Landesanstalt Abh., new ser., vol. 111, p. 168, pl. 15, fig. 13. SANDIDGE, *1932*, Am. Midland Nat., vol. 13, p. 337, pl. 31, fig. 2.[7] Brotzen, *1934*, Zeitschr. Deutschen Palästina-Vereins, Jahrg. 1934, p. 61.

Test medium large, planispiral, moderately compressed, with large involute initial coil and medium-short, narrow uncoiled portion, umbilicus excavated, peripheral margin evenly rounded; chambers indistinct; sutures poorly marked, flush with surface of test; wall thick, medium coarsely granular, of clear quartz grains; aperture simple, terminal.

Dimensions of hypotype, from I.P.Co. well 1755, 2460 feet depth: height, 1.36 mm.; width of initial coil, 0.56 mm.; thickness, 0.20 mm.

Comparison with a topotype of *A. agglutinans* from the Miocene of the Vienna basin showed no detectable differences, either in shape, structure, or grain size. The characters stressed are shape, and in particular the excavated umbilicus.

AMMOBACULITES sp.
Plate 55, figure 10

Test medium large, planispiral, much compressed, with large involute initial coil and short uncoiled portion, umbilicus not excavated, peripheral margin slightly crenulate, a thread-like keel on periphery; 5 chambers in initial coil, triangular; sutures straight, thickened, flush with surface; wall moderately thin, finely granular; aperture simple, terminal.

Dimensions of hypotype, from I.P.Co. well 1755, 2670 feet depth: height, 1.50 mm.; width, 1.04 mm.; thickness, 0.23 mm.

A single specimen has been found. Until more material is available, the species cannot be identified with any degree of certainty.

[7] The interrogation mark (?) preceding a citation implies a question as to the identity of other specimens with those from the Mal Paso shale. Thus, I regard *A. agglutinans* from Peru as identical with "*Spirolina*" *agglutinans* d'Orbigny, without being certain that the forms identified by Franke, Sandidge, and Brotzen are necessarily conspecific with it.

Subfamily LITUOLINAE
Genus CYCLAMMINA H. B. Brady, 1876
CYCLAMMINA GARCILASSOI
Frizzell, n. sp.
Plate 55, figures 11a, b

Test of medium size, planispiral, involute, slightly higher than wide, umbilicus excavated, moderately compressed, peripheral margin crenate; chambers 10 to 13 in last whorl, thickened near umbilicus, sloping down to rounded periphery, typically mechanically compressed, with a false keel due to distortion; sutures sinuous, directed forward in outer half of radius, incised; wall thick, coarsely perforate, smooth, vitreous in texture; aperture a curved slit at base of septal face.

Dimensions of holotype, from I.P.Co. well 1755, 1990 feet depth: height, 1.56 mm.; thickness, 0.51 mm.

The species is named for Garcilasso Inca de la Vega, Spanish-Indian chronicler of the Peruvian conquest.

Family TEXTULARIIDAE
Subfamily SPIROPLECTAMMINAE
Genus SPIROPLECTAMMINA Cushman, 1927

Macfadyen (1933) resurrected the genus *Bolivinopsis* Yakovlev (1891, p. 349) to replace the calcareous genus *Spiroplectoides* Cushman (1927, p. 77), a change which has been adopted in a recent revision of the Foraminifera (1940, p. 231). Although it is obvious that the name *Bolivinopsis* must replace either *Spiroplectoides* Cushman or *Spiroplectammina* Cushman, the case is not clearcut.

Yakovlev's material, according to Macfadyen, consisted of preparations in canada balsam. Although Yakovlev stated that all of his species were "*Perforata calcarea*," it is not definitely known that he had applied acid to test the specimens of *Bolivinopsis*. At the Cushman Laboratory for Foraminiferal Research, in 1940, it was demonstrated conclusively that a group of competent observers was unable to differentiate solely by visual examination, in certain cases, finely arenaceous (partially recrystallized?) from calcareous tests. This was particularly true of specimens which have been referred variously to *Spiroplectammina*, *Spiroplectoides*, and *Bolivinopsis*.

Although the genotypic species *B. capi-*

lata Yakovlev is extremely similar in shape to *Spiroplectoides rosula* (Ehrenberg), the genotype of *Spiroplectoides*, there is no *a priori* reason to assume that the two forms are necessarily identical. On the contrary, they may well belong to fundamentally unrelated families. In short, until it has been possible for someone to rework the genera involved, and from topotypic specimens, *Bolivinopsis* Yakovlev must be regarded as a *nomen dubium*.

SPIROPLECTAMMINA GRZYBOWSKII
Frizzell, n. sp.
Plate 55, figures 12a, b, 13

Spiroplectoides clotho (Grzybowski). Cushman and Jarvis, 1928, Cushman Lab. Foram. Res. Contr., vol. 4, p. 101, pl. 14, figs. 13, 14.

Spiroplectoides(?) clotho (Grzybowski). CUSHMAN, *1934*, Cushman Lab. Foram. Research Contr., vol. 10, pt. 2, pp. 42–43, pl. 6, figs. 20–23 (not fig. 19) (not *Spiroplecta clotho* Grzybowski, *1901*, Rozprawy Akad. Umiej. (Mat.-Przyrod.), vol. 41, p. 283, pl. 7, fig. 18).

?Spiroplectammina rosula (Ehrenberg). GALLOWAY and MORREY, *1931*, Jour. Paleontology, vol. 5, no. 4, p. 335, pl. 37, fig. 10 (not *Spiroplectoides rosula* (Ehrenberg)).

Bolivinopsis clotho (Grzybowski). CUSHMAN, *1940*, Foraminifera, etc., ed. 3, key pl. 26, figs. 2–3 (not *B. clotho* (Grzybowski), NUTTALL, *1935*, Jour. Paleontology, vol. 9, no. 2, pp. 125–126, pl. 14, figs. 23–24).

This relatively well known species has been adequately described by Cushman, who published a complete synonymy. The holotype selected is that specimen in the Cushman collection figured by Cushman and Jarvis (1928, p. 101, pl. 14, figs. 13, 14).

Dimensions of holotype (megalospheric individual), from I.P.Co. well 1755, 2310 feet depth: height, 1.27 mm.; width, 0.32 mm.; thickness, 0.14 mm.

Dimensions of paratype (microspheric individual), from I.P.Co. well 1755, 1960 feet depth: height, 1.42 mm.; width, 0.36 mm.; thickness, 0.14 mm.

The recognition of a number of closely allied species of *Spiroplectammina*, ranging from Cretaceous to Recent age, suggests that *S. grzybowskii* and *S. clotho* are distinct and the proposal of a name for the specimens under consideration serves to emphasize the stratigraphic and geographic distribution of the characteristic American form. The species is named in honor of J. Grzybowski, who not only contributed to knowledge of the Cretaceous Foraminifera of Europe, but in addition undertook pioneer field work in northwestern Peru.

S. grzybowskii is believed to occur in the middle and upper Mendez shale of Mexico (White, 1929, p. 32). Comparison of the Mal Paso form with specimens from the Tamesí formation of Mexico and the Tarouba formation (Lizard Springs beds) of Trinidad show close similarity, even in the differences between microspheric and megalospheric forms. Moreover, both forms are composed of definite, although extremely fine grained arenaceous material.

This species appears to be most closely related to *S. californica* (Cushman and Campbell) (1934, pp. 70–71, pl. 9, figs. 15–17), described from the upper part of the Chico formation of the Upper Cretaceous of central California, and reported from the uppermost Cretaceous Moreno shale of the same region. The latter differs, however, in its less lanceolate and straighter sided microspheric form; and in the less well developed initial whorl of the megalospheric form. In addition, *S. californica*, as figured, appears to be more inflated in the biserial portion.

Spiroplectammina parallela Cushman (1931a, p. 26, pl. 4, fig. 1), from the late Tertiary of the Fiji Islands and the living fauna in the Pacific Ocean, belongs to the same group as *S. grzybowskii*. It is distinguished, however, by its smaller size, indistinct chambers in the initial whorl, and the tendency of the biserial portion to decrease in size toward the aperture.

Galloway and Morrey have placed the megalospheric generation of "*S. clotho*" from Trinidad in the synonymy of "*Spiroplectammina*" *rosula* (Ehrenberg), which they recorded from the late Cretaceous of Tabasco, Mexico. The specimen figured by them is very much like *Spiroplectoides rosula*, but has been questionably referred by Cushman (1934, p. 43) to *S. spectabilis* (Grzybowski). Galloway and Morrey described the form from Mexico as finely arenaceous.

Nuttall recorded *Bolivinopsis clotho* (Grzybowski) from the upper part of the upper Eocene, Pauji shale, of Venezuela. This form, however, apparently is identical with an Eocene species found in the Talara

to Verdun formations of northwestern Peru, and appears to be specifically distinct from *Spiroplectammina grzybowskii*.

Family VERNEUILINIDAE
Genus GAUDRYINA d'Orbigny, 1840
GAUDRYINA sp.
Plate 55, figure 9

Badly crushed specimens, similar to forms occurring throughout the Peruvian Eocene section, are not uncommon in the Mal Paso shale. Because of their preservation, it has not been possible to identify these individuals specifically.

Dimensions of hypotype, from I.P.Co. well 1755, 3040 feet depth: height, 0.90 mm.; diameter, 0.19 mm.

Genus PSEUDOCLAVULINA Cushman, 1936
PSEUDOCLAVULINA CLAVATA (Cushman)
Plate 55, figure 14

Pseudoclavulina clavata (Cushman). CUSHMAN, *1937*, Cushman Lab. Foram. Research, Spec. publ. no. 7, p. 108, pl. 15, figs. 1–13.

A synonymy and adequate description of this species have been given by Cushman. *P. clavata* ranges from the upper part of the Austin chalk of Texas, through the Tamesi formation of Mexico, and is irregularly distributed in the Mal Paso shale.

Dimensions of hypotype, from I.P.Co. well 1832, 3300 feet depth: height, 2.28 mm.; diameter, 0.60 mm.

The identification of this species is based largely on comparison with specimens identified by Cushman. The holotype is poorly preserved, and does not closely resemble other specimens referred to the species. Closest to the Mal Paso form is "*Clavulina amorpha* Cushman" (1931, p. 21, pl. 1, figs. 12–13; not 1926, p. 589, pl. 17, fig. 3, from the Tamesi formation of Mexico).

Family VALVULINIDAE
Genus MARSSONELLA Cushman, 1933
MARSSONELLA OXYCONA (Reuss)
Plate 55, figures 15a, b

Gaudryina oxycona Reuss. CUSHMAN and JARVIS *1932*, U. S. Nat. Mus. Proc., vol. 80, art. 14, p. 18, pl. 5, figs. 1, 2.
Marssonella oxycona (Reuss). CUSHMAN, *1937*, Cushman Lab. Foram. Research Spec. Publ. no. 8, pp. 56–59, pl. 5, figs. 27–29, pl. 6, figs. 1–15.

The name *Marssonella oxycona* (Reuss) has been applied to a number of dissimilar forms, and apparently represents a variable species with a wide geographic and stratigraphic range. A detailed description and discussion have been given by Cushman. The single specimen from the Mal Paso shale is quite similar to the specimen figured by Cushman and Jarvis, even in color and preservation.

Family TROCHAMMINIDAE
Subfamily TROCHAMMININAE
Genus TROCHAMMINA Parker and Jones, 1859
TROCHAMMINA GLOBIGERINIFORMIS (Parker and Jones)
Plate 55, figures 16a, b

Lituola nautiloidea var. *globigeriniformis* PARKER and JONES, Phil. Trans., vol. 155, p. 407, pl. 15, figs. 46, 47 (not pl. 17, figs. 96–98).
Trochammina globigeriniformis (Parker and Jones). CUSHMAN and JARVIS, *1932*, U. S. Nat. Mus. Proc., vol. 80, art. 14, p. 21, pl. 6, figs. 2–5.

Test large, trochoid, moderately compressed, dorsal surface slightly convex, ventral surface nearly flat, periphery rounded, early chambers visible on dorsal side, only last whorl visible on ventral side, margin crenate; 4 chambers in last whorl, inflated although generally collapsed, moderately overlapping, subspherical; sutures depressed, curved; wall relatively thick, finely granular, composed of quartz grains; aperture not evident on specimens examined.

Dimensions of hypotype, from I.P.Co. well 1755, 2980 feet depth: height, 0.49 mm.; diameter, 1.29.

The Mal Paso specimens are identical with specimens from the Cretaceous of Trinidad which have been referred to this species. They agree well with the figures of Parker and Jones, although a Recent specimen is considerably smaller.

TROCHAMMINA ONDEGARDOI Frizzell, n. sp.
Plate 55, figures 18a–c

Test large, depressed trochoid, all chambers visible on dorsal side, last whorl only visible on ventral side, dorsal side slightly convex, ventral side moderately convex, margin slightly crenulate, umbilicus excavated; 8 chambers in last whorl, most inflated near umbilicus, sloping down to acutely rounded periphery; sutures poorly

marked, slightly depressed, apparently sinuous; wall medium thick, finely granular to vitreous in texture; aperture a slit at base of apertural face, extending from peripheral margin about halfway to umbilicus.

Dimensions of holotype, from I.P.Co. well 1755, 2550 feet depth: height, 0.34 mm.; diameter, 0.97 mm.

Trochammina ondegardoi is one of the most abundant forms in the Mal Paso samples. It is generally crushed, and can be distinguished only with difficulty from crushed and distorted specimens of *Trochammina globigeriniformis* and various species of *Haplophragmoides*. No similar forms have been found with which this species can be closely compared.

The species is named for Polo de Ondegardo, contemporary of the Peruvian conquest.

TROCHAMMINA? LEJESEMAI Frizzell, n. sp.
Plate 55, figures 17a, b

Test trochoid, large, extremely compressed, periphery crenate; chambers variable, 8 to 10 in last whorl, apparently collapsed; sutures poorly marked, slightly depressed; wall composed of very fine quartz grains and apparently siliceous cement, exterior finely granular to vitreous; aperture not visible on specimens examined.

Dimensions of holotype, from I.P.Co. well 3040, 1985 feet depth: height, 0.16 mm.; diameter, 1.16 mm.

This flattened form is distinct, as nearly as can be determined, from other described species. It is common in the Mal Paso shale.

The species is named for Mancio Sierra Lejesema, Spanish soldier of the Conquest.

Family LAGENIDAE
Subfamily NODOSARIINAE
Genus ROBULUS Montfort, 1808
ROBULUS sp. cf. R. DISCREPANS (Reuss)
Plate 55, figures 19a, b

?Robulina discrepans REUSS, *1863*, Akad. Wiss. Wien, Math.-naturwiss. Kl., Sitzungser., vol. 46, pt. 1, "1862," p. 78, pl. 9, figs. 7a, b.
?Robulus discrepans (Reuss). CUSHMAN and JARVIS, *1932*, U. S. Nat. Mus. Proc., vol. 80, art. 14, p. 23, pl. 7, figs. 4a, b.

Test of medium size, planispiral, later chambers at one side of plane of coiling as in the genus *Darbyella*, involute, higher than wide, moderately tumid, periphery evenly rounded, with slight keel; chambers triangular in cross section, increasing rapidly in size with age, 8 or 9 in last whorl; sutures flush with surface, thickened, curving backward broadly; wall smooth, finely perforate, unornamented; aperture at angle of septal face with periphery, radiate, circular.

Dimensions of hypotype, from I.P.Co. well 1755, 3020 feet depth: height, 0.96 mm.; thickness, 0.34 mm.

This *Lenticulina*-like species is quite variable, but the more typical specimens are very similar to the example figured by Cushman and Jarvis from the Cretaceous of Trinidad. The species is moderately common in the Mal Paso shale.

ROBULUS? CAPAC Frizzell, n. sp.
Plate 56, figures 1a, b

Test large, planispiral, involute, outline nearly circular, compressed, umbo with raised plaited boss, periphery evenly rounded, with well-developed keel; chambers triangular, about 10 in last whorl, increasing in size evenly with age; sutures moderately recurved, slightly raised; wall smooth; aperture broken in holotype.

Dimensions of holotype, from I.P.Co. well 1755, 2120 feet depth: height, 2.70 mm.; thickness, 0.74 mm.

This extremely rare form appears to be markedly different from any species available for comparison. The trivial name *capac* is a Quechua word signifying great or powerful.

Genus LENTICULINA Lamarck, 1804
LENTICULINA ROTULATA (Lamarck)
Plate 56, figures 2a, b

?Lenticulites rotulata LAMARCK, *1804*, Ann. Mus., vol. 5, p. 188, no. 3.

The name *L. rotulata* is applied here to nearly circular, moderately inflated specimens, smooth except when eroded, with clear calcareous material at the umbo but without umbonal boss. They are not well enough preserved, nor are the various species of *Lenticulina* and related genera well enough differentiated at the present time, to justify any closer attempt at identification or description.

Dimensions of hypotype, from I.P.Co. well 2000, 2335–2370 feet depth: height, 0.90 mm.; thickness, 0.42 mm.

Genus MARGINULINA d'Orbigny, 1826

MARGINULINA sp. cf. M. BULLATA Reuss
Plate 56, figure 3

?Marginulina bullata REUSS, *1845–1846*, Verstein. Böhm. Kreide., pt. 1, p. 29, pl. 13, figs. 34–38.

Marginulina bullata Reuss. CUSHMAN and JARVIS, *1932*, U. S. Nat. Mus. Proc., vol. 80, art. 14, pp. 26–27, pl. 8, figs. 7–8.

Test of medium size, with close coiled initial whorl and uncoiled later portion in microspheric form, megalospheric form uncoiled from initial chamber; chambers 5 to 7, 3 to 4 in uncoiled portion of test, inflated except in initial whorl of microspheric form, width of chambers about one-half height; sutures impressed in later chambers, flush with surface in earlier chambers, slightly oblique; wall smooth, unornamented; aperture circular, radiate, subcentral, about one-third distance from peripheral margin.

Dimensions of hypotype, from I.P.Co. well 2000, 2370 feet depth: height, 0.76 mm.; diameter, 0.37 mm.

Four specimens from the Mal Paso shale are referred to this species, two being quite similar to the figured specimens from Trinidad. The Mal Paso form appears to be variable, and will require additional specimens for positive identification.

MARGINULINA TEXENSIS Cushman
Plate 56, figure 4

Marginulina texensis CUSHMAN, *1937*, Cushman Lab. Foram. Research Contr., vol. 13, p. 95, pl. 14, figs. 2–4.

Marginulina texensis Cushman, 1928, Cushman Lab. Foram. Res. Contr., vol. 14, p. 95.

Test medium large, elongate, with short initial coil and long uncoiled portion, slightly compressed dorsoventrally, tumid laterally, dorsal margin nearly straight, ventral margin straight in anterior third of test, crenate in last 3 chambers; chambers 4 to 6 in initial

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EXPLANATION OF PLATE 55

Magnifications approximate.

FIGS. *1*—*Bathysiphon carapitanus* Hedberg. Lateral view of hypotype, I.P.Co. well 1755, 2110 feet depth, ×16.5. (p. 335)

2—*Bathysiphon taurinensis* Sacco. Lateral view of hypotype, I.P.Co. well 1755, 1950 feet depth, ×16.5. (p. 336)

3—*Pelosina scruposa* (Berthelin). Apertural view of hypotype, I.P.Co. well 1755, 2250 feet depth, ×16.5. (p. 337)

4—*Pelosina complanata* Franke. Apertural view of hypotype, I.P.Co. well 1755, 2750 feet depth, ×16.5. (p. 336)

5a, b—*Haplophragmoides atahuallpai* Frizzell, n. sp. Holotype, I.P.Co. well 1755, 2550 feet depth, ×25. *a*, lateral view; *b*, peripheral view. (p. 337)

6a, b—*Haplophragmoides zaratei* Frizzell, n. sp. Holotype, I.P.Co. well 2174, 3180 feet depth, ×16.5. *a*, lateral view; *b*, peripheral view. (p. 337)

7a, b—*Haplophragmoides* sp. aff. *H. deformis* (Andreae). Hypotype, I.P.Co. well 1755, 1990 feet depth, ×25. *a*, lateral view; *b*, peripheral view. (p. 337)

8—*Ammobaculites agglutinans* (d'Orbigny). Lateral view of hypotype, I.P.Co. well 1755, 2460 feet depth, ×20. (p. 338)

9—*Gaudryina* sp. Lateral view of hypotype, I.P.Co. well 1755, 3040 feet depth, ×30. (p. 340)

10—*Ammobaculites sp.* Lateral view of hypotype, I.P.Co. well 1755, 2670 feet depth, ×16.5. (p. 338)

11a, b—*Cyclammina garcilassoi* Frizzell, n. sp. Holotype, I.P.Co. well 1755, 1990 feet depth, ×16.5. *a*, lateral view; *b*, peripheral view. (p. 338)

12a, b, 13—*Spiroplectammina grzybowskii* Frizzell, n. sp. *12a, 12b*, lateral and apertural views of holotype, I.P.Co. well 1755, 2310 feet depth, ×25. *13*, lateral view of paratype, I.P.Co. well 1755, 1960 feet depth, ×25. (p. 339)

14—*Pseudoclavulina clavata* (Cushman). Lateral view of hypotype, I.P.Co. well 1832, 3300 feet depth, ×16.5. (p. 340)

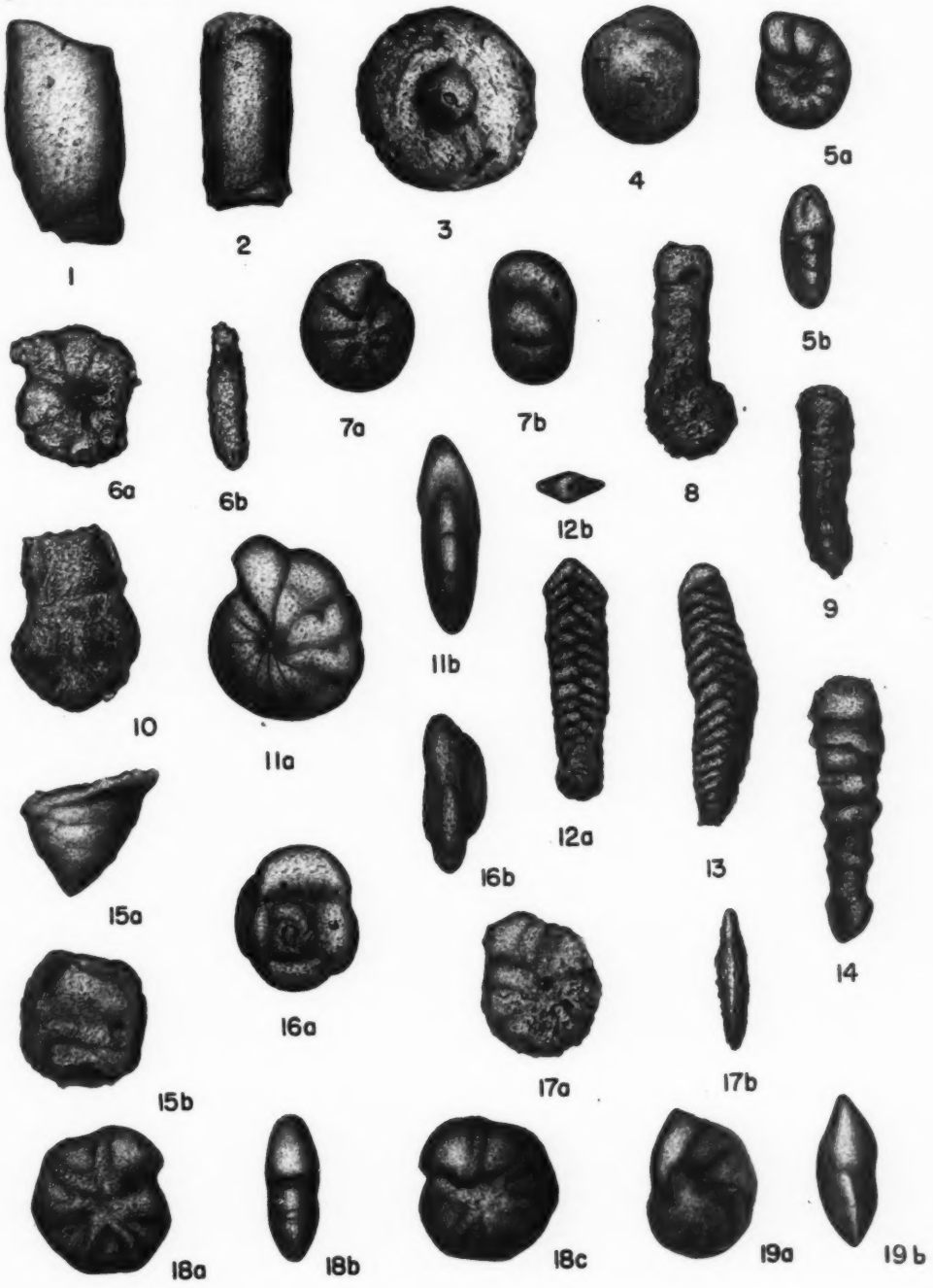
15a, b—*Marssonella oxycona* (Reuss). Hypotype, I.P.Co. well 1755, 2980 feet depth, ×20. *a*, lateral view; *b*, apertural view. (p. 340)

16a, b—*Trochammina globigeriniformis* (Parker and Jones). Hypotype, I.P.Co. well 1755, 2980 feet depth, ×16.5. *a*, dorsal view; *b*, peripheral view. (p. 340)

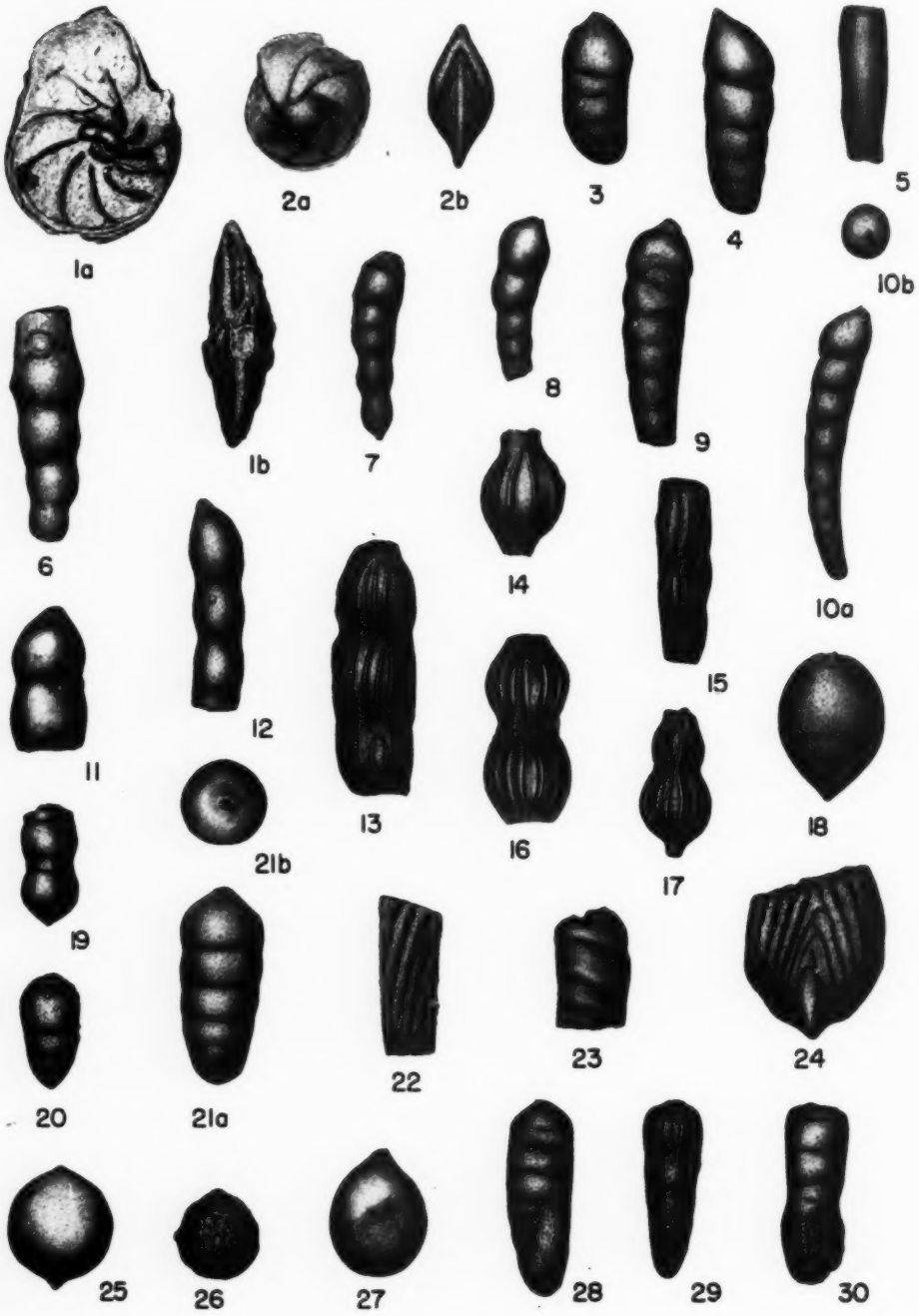
17a, b—*Trochammina? lejesemai* Frizzell, n. sp. Holotype, I.P.Co. well 3040, 1985 feet depth, ×16.5. *a*, lateral view; *b*, peripheral view. (p. 340)

18a–c, Trochammina ondegardoi Frizzell, n. sp. Holotype, I.P.Co. well 1755, 2550 feet depth, ×20. *a*, ventral view; *b*, peripheral view; *c*, dorsal view. (p. 340)

19a, b—*Robulus* sp. cf. *R. discrepans* (Reuss). Hypotype, I.P.Co. well 1755, 3020 feet depth, ×20. *a*, lateral view; *b*, peripheral view. (p. 341)



Frizzell, Cretaceous Foraminifera



Frizzell, Cretaceous Foraminifera

whorl, 5 in uncoiled portion, tumid, last 3 chambers rounded dorsally; sutures slightly impressed, oblique; aperture circular, radiate, protuberant, at the peripheral margin.

Dimensions of hypotype, from I.P.Co. well 1755, 2310 feet depth: height, 1.07 mm.; width, 0.39 mm.; thickness, 0.36 mm.

This species is very similar to some of the variants of *M. texensis*. It is moderately rare in the Mal Paso shale.

MARGINULINA COYA Frizzell, n. sp.
Text-figure 2

Test medium large, elongate, slender, with rapidly uncoiling initial part and predominant uncoiled portion, sides nearly straight in first half of test and becoming crenate in last chambers; 3 chambers in initial part, 6 or more chambers in linear portion, circular in cross section, last 2 or more chambers moderately inflated; sutures flush with surface in early part of test, moderately im-

EXPLANATION OF PLATE 56
Magnifications approximate.

FIGS. *1a, b—Robulus? capac* Frizzell, n. sp. Holotype, I.P.Co. well 1755, 2120 feet depth, ×11. *a*, lateral view; *b*, peripheral view. (p. 341)
2—"Lenticulina rotulata (Lamarck)." Hypotype, I.P.Co. well 2000, 2335–2370 feet depth, ×20. *a*, lateral view; *b*, peripheral view. (p. 341)
3—Marginulina sp. cf. *M. bullata* Reuss. Lateral view of hypotype, I.P.Co. well 2000, 2370 feet depth, ×25. (p. 342)
4—Marginulina texensis Cushman. Lateral view of hypotype, I.P.Co. well 1755, 2310 feet depth, ×25. (p. 342)
5—Dentalina? sp. cf. *D. consobrina* d'Orbigny. Lateral view of hypotype, I.P.Co. well 1755, 2910 feet depth, ×25. (p. 344)
6—Dentalina? sp. C. Lateral view of specimen, I.P.Co. well 1755, 2500 feet depth, ×25. (p. 345)
7, 8—Dentalina sp. cf. *D. wimani* Brotzen. *7*, lateral view of hypotype, I.P.Co. well 1755, 3000 feet depth, ×35. *8*, lateral view of hypotype, I.P.Co. well 1755, 2310 feet depth, ×25. (p. 344)
9, 10—Dentalina oviedoi Frizzell, n. sp. *9*, lateral view of paratype, I.P.Co. well 1755, 2170 feet depth, ×20. *10*, lateral and apertural views of holotype, I.P.Co. well 1755, 2530 feet depth, ×32.5. (p. 344)
11, 19—Dentalina sp. A. *11*, lateral view of specimen, I.P.Co. well 2000, 2370 feet depth, ×25. *19*, lateral view of specimen, I.P.Co. well 1755, 3020 feet depth, ×25. (p. 345)
12—Dentalina sp. B. Lateral view of specimen, I.P.Co. well 1832, 3420 feet depth, ×25. (p. 345)
13, 16—Nodosaria pozoensis W. Berry. Lateral views of hypotypes (virtual topotypes), I.P.Co. well 1755, 2180 feet depth, ×16.5. (p. 345)
14—Nodosaria sp. aff. *N. distans* Reuss. Lateral view of hypotype, I.P.Co. well 2000, 2315 feet depth, ×35. (p. 345)
15—Nodosaria sp. Lateral view of hypotype, I.P.Co. well 2000, 2370 feet depth, ×16.5. (p. 346)
17—Nodosaria sp. cf. *N. pozoensis* W. Berry. Lateral view of hypotype, I.P.Co. well 1755, 2150 feet depth, ×16.5. (p. 346)
18—Pseudoglandulina sp. cf. *P. inflata* (Bornemann). Lateral view of hypotype, I.P.Co. well 1755, 2540 feet depth, ×40. (p. 347)
20, 21—Pseudoglandulina marginuliniformis Frizzell, n. sp. *20*, lateral view of paratype, I.P.Co. well 2000, 2315 feet depth, ×25. *21*, lateral and apertural views of holotype, I.P.Co. well 2841, 2915 feet depth, ×25. (p. 347)
22—Vaginulina sp. A. Lateral view of hypotype, I.P.Co. well 1755, 3020 feet depth, ×20. (p. 347)
23—Vaginulina sp. B. Lateral view of hypotype, I.P.Co. well 2841, 2915 feet depth, ×20. (p. 348)
24—Frondicularia sp. Lateral view of hypotype, I.P.Co. well 1755, 2830 feet depth, ×20. (p. 348)
25—Lagena? malpasoensis Frizzell, n. sp. Lateral view of holotype, ×35. (p. 348)
26—Lagena hexagona (Williamson). Lateral view of hypotype, I.P.Co. well 1755, 3000 feet depth, ×35. (p. 348)
27—Globulina lacrima (Reuss). Lateral view of hypotype, I.P.Co. well 1755, 2900 feet depth, ×25. (p. 348)
28—Siphogenerinoides cretacea Cushman. Lateral view of hypotype, I.P.Co. well 2616, 1850 feet depth, ×16.5, "*Clavulina*" shale. (p. 349)
29—Siphogenerinoides plummeri (Cushman) var. *coya* Frizzell, n. var. Lateral view of holotype, I.P.Co. well 3040, 1945 feet depth, ×32.5. (p. 349)
30—Siphogenerinoides clarki Cushman and Campbell. Lateral view of hypotype, I.P.Co. well 2616, 1790 feet depth, ×32.5, "*Clavulina*" shale. (p. 349)

pressed between last chambers, straight except in initial whorl; wall smooth, unornamented; aperture large, central, circular, radiate, protuberant.

Dimensions of holotype, from I.P.Co. well 2000, 2335–2370 feet depth: height, 1.62 mm.; diameter, 0.49 mm.

Dimensions of paratype, from I.P.Co. well 2000, 2335–2370 feet depth: height, 1.00 mm.; diameter, 0.60 mm.

Marginulina coya resembles *M. dorsata* Cushman (1937, p. 94, pl. 13, figs. 16–18), but is circular rather than compressed in cross section. It is further distinguished by the protuberant central aperture. *M. coya* bears some resemblance to *M. gardnerae* Plummer (1927, p. 106, pl. 5, figs. 11a–c), but is straight rather than curved, and may be separated as well by the central aperture.

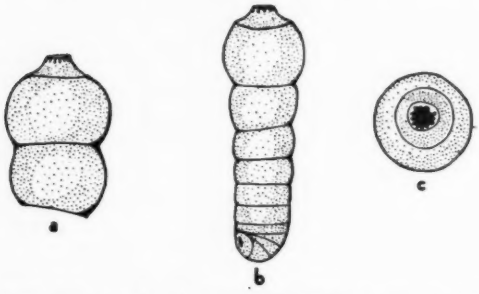


FIG. 2—*Marginulina coya* Frizzell, n. sp. *a*, *c*, lateral and apertural views of paratype, from I.P.Co. well No. 2000, 2335–2370 feet depth, ×21; *b*, lateral view of holotype, from I.P.Co. well No. 2000, 2335–2370 feet depth, ×21.

The specific name *coya*, from one of the Incaic dialects of Peru, is translated as "queen." It therefore must be regarded as a noun in apposition, and cannot change with possible generic changes.

Genus DENTALINA d'Orbigny, 1826

DENTALINA? sp. cf. D. CONSOBRINA d'Orbigny

Plate 56, figure 5

?Dentalina consobrina D'ORBIGNY, *1846*, Foram. Foss. Vienne, p. 46, pl. 2, figs. 1–3.

Dentalina cf. *consobrina* d'Orbigny. CUSHMAN and HEDBERG, *1941*, Cushman Lab. Foram. Research Contr., vol. 17, pt. 4, p. 89, pl. 21, figs. 30, 31.

Dentalina filiformis Reuss?. CUSHMAN and JARVIS, *1932*, U. S. Nat. Mus. Proc., vol. 80, art. 14, p. 29, pl. 9, figs. 6, 7.

Several single chambers have been encountered, which appear to be identical with Cretaceous species of *Dentalina*. They are not closely similar to the original figures of *D. consobrina* d'Orbigny, nor of *D. filiformis* (Reuss) (1845, p. 28, pl. 12, figs. 28 a–b, as *Nodosaria*). Because of the fragmentary nature of these specimens, neither genus nor species can be definitely determined.

Dimensions of hypotype (single chamber) from I.P.Co. well 1755, 2910 feet depth: height, 0.83 mm.; diameter, 0.22 mm.

DENTALINA OVIEDOI Frizzell, n. sp.

Plate 56, figures 9, 10a, b

Test of medium size, elongate, slightly arched, moderately compressed; chambers about 9, width slightly more than twice height, later chambers somewhat inflated; sutures incised, slightly oblique; wall smooth, unornamented; aperture radial, terminal, subcentral, produced.

Dimensions of holotype, from I.P.Co. well 1755, 2530 feet depth: height, 1.10 mm.; width, 0.20 mm.; thickness, 0.17 mm.

Dimensions of paratype, from I.P.Co. well 1755, 2170 feet depth: height, 1.50 mm.; width, 0.43 mm.; thickness, 0.26 mm.

This species belongs to the slightly compressed, moderately arched group of *Dentalina*, with more or less incised chambers. Two complete and one broken specimens are at hand, none agreeing exactly with described species available for comparison. Although monographic treatment of the group may show these to belong to a described species, it seems desirable to refer them to a new species.

The specific name is given in honor of Gonzalo Fernandez de Oviedo, contemporary of the Conquest of Peru, whose manuscript reports have been widely quoted.

DENTALINA sp. cf. D. WIMANI Brotzen

Plate 56, figures 7, 8

?Dentalina wimani BROTZEN, *1936*, Sveriges geol. undersökning, ser. C, no. 396, vol. 30, no. 3, pp. 76, 77, pl. 5, figs. 15, 16.

Dentalina cf. *wimani* Brotzen. CUSHMAN and HEDBERG, *1941*, Cushman Lab. Foram. Research Contr., vol. 17, pt. 4, p. 89, pl. 21, figs. 25, 26.

Several rather poorly preserved specimens appear to be identical with forms from the Colon shale of Colombia, and possibly with *D. wimani* Brotzen from the Upper Cretaceous of Sweden. Better preserved speci-

mens will be needed to establish the identity.

Dimensions of hypotype, from I.P.Co. well 1755, 3000 feet depth: height, 0.67 mm.; width, 0.19 mm.; thickness, 0.17 mm.

Dimensions of hypotype, from I.P.Co. well 1755, 2310 feet depth: height, 0.84 mm.; width, 0.26 mm.; thickness, 0.24 mm.

DENTALINA sp. A
Plate 56, figures 11, 19

Several broken specimens were found of a form similar to *D. fallax* Franke (1928, p. 27, pl. 2, fig. 18), but much larger. Although these appear to belong to an undescribed species, better specimens are required to establish its characteristics and range of variation.

Dimensions of specimen, from I.P.Co. well 2000, 2370 feet depth: height, 0.74 mm.; diameter, 0.36 mm.

Dimensions of hypotype, from I.P.Co. well 1755, 3020 feet depth: height, 0.62 mm.; diameter, 0.32 mm.

DENTALINA sp. B
Plate 56, figure 12

Rare specimens were found of a very slender, medium-large species of *Dentalina*, with slightly inflated chambers. Because of the variability of species of this genus, as well as the poor preservation of the specimens, it has not been possible to make an identification.

Dimensions of specimen, from I.P.Co. well 1832, 3420 feet depth: height, 1.06 mm.; width, 0.29 mm.; thickness, 0.26 mm.

DENTALINA? sp. C
Plate 56, figure 6

Test of medium size, elongate, medium slender, gradually tapering; chambers in slightly curved line, 5 in broken specimen, circular in cross section, slightly inflated, increasing in size from first chamber to near end of test, then decreasing in size; sutures straight, impressed; wall smooth.

Dimensions of specimen (broken), from I.P.Co. well 1755, 2500 feet depth: height, 1.17 mm.; width, 0.43 mm.; thickness, 0.37 mm.

It has not been possible to identify this form with any described species but because of the fragmentary and poorly preserved specimens a new species is not proposed.

Genus NODOSARIA Lamarck, 1812

NODOSARIA sp. aff. N. DISTANS Reuss
Plate 56, figure 14

?Nodosaria distans REUSS, *1855*, Zeitschr. deutsch. Gesell., vol. 7, p. 264, pl. 8, fig. 5.

Three specimens were found of a considerably constricted, rather large, medium coarsely ribbed form, apparently related to *N. distans* Reuss. They appear, however, to be more constricted than that species, with more numerous ribs, and may be distinct.

Dimensions of hypotype (broken specimen), from I.P.Co. well 2000, 2315 feet depth: height, 0.49 mm.; diameter, 0.33 mm.

NODOSARIA POZOENSIS W. Berry
Plate 56, figures 13, 16

Nodosaria pozoensis W. BERRY, 1931, Washington Acad. Sci. Jour., vol. 21, no. 17, p. 415, text-fig. 1.

Nodosaria paupercula Reuss. CUSHMAN and JARVIS, *1932*, U. S. Nat. Mus. Proc., vol. 80, art. 14, pp. 33–34, pl. 10, figs. 14, 15 (not of Reuss, 1845–1846).

Test very large, straight; chambers numerous, large, typically subspherical, increasing in size very slightly if at all from initial portion of test; sutures straight, impressed; wall ornamented with heavy ribs, from 12–16 on each chamber, continuous across suture in some specimens, more commonly discontinuous or flexed at the suture; aperture not visible on specimens examined.

Dimensions of hypotypes (broken specimens), from I.P.Co. well 1755, 2180 feet depth: height, 2.10 mm.; diameter, 0.67 mm.; height, 1.56 mm.; diameter, 0.76 mm.

This species is represented by broken tests, showing a moderate amount of variation. The specimens from the Cretaceous of Trinidad are very close to topotypes of Berry's species. From the figures and description of *N. paupercula* Reuss, it would seem that Peruvian and Trinidad specimens might be regarded as representing a distinct species. Specimens from the Cretaceous referred to *N. affinis* Reuss have less constricted sutures.

Nodosaria pozoensis was described from I.P.Co. well 1920 (Square mile 1-N-2, 1548 feet north and 876 feet east), from a depth of 1980 feet, in the Mal Paso shale, and occurs sporadically throughout that formation. The trivial name is misleading, being derived from the Spanish *pozo* (a well)

rather than indicating any occurrence in the Pozo shale (Eocene) of the region.

NODOSARIA sp. cf. N. POZOENSIS W. Berry
Plate 56, figure 17

The specimen figured shows a pointed initial chamber, which is not in agreement with the rounded initial chamber reported in the original description of *N. pozoensis*. Although this form is believed to belong to Berry's species, it tentatively is separated, pending more adequate material for study.

Dimensions of hypotype, from I.P.Co. well 1755, 2150 feet depth: height, 1.19 mm.; diameter, 0.56 mm.

NODOSARIA sp.
Plate 56, figure 15

A single specimen has been found of a large, slightly constricted *Nodosaria*, with nearly obsolete coarse ribs. This may be a variant of *N. pozoensis*, but it appears to be distinct, particularly as the sutures are not impressed.

Dimensions of hypotype, from I.P.Co. well 2000, 2370 feet depth: height, 1.43 mm.; diameter, 0.50 mm.

Genus PSEUDOGLANDULINA Cushman, 1929

The position of the genus *Pseudoglandulina* in the family Lagenidae has been recognized by Cushman (1940, pp. 194–203).[8] According to his diagrammatic representation of relationships within the family Lagenidae, *Marginulina* gave rise to *Dentalina*, *Dentalina* to *Nodosaria*, and *Nodosaria* to *Pseudoglandulina*. These conclusions were based primarily upon comparative morphology, with some chronogenetic support.[9]

[8] The family Lagenidae, as accepted here, is that of traditional usage, as revised by Cushman. It is unfortunate that a polyphyletic genus, consisting of overspecialized members of a number of unrelated groups, should have been made the type of an important family. Little could be accomplished in this case, however, by any mere change of name or type genus, without a complete, detailed, monographic revision of the family.

[9] *Nodosaria* is listed by Cushman from the Triassic and perhaps earlier, whereas its supposed ancestor, *Dentalina*, is recorded from rocks no older than Jurassic. This apparent anachronism, however, does not necessarily invalidate the postulated evolutionary sequence.

EXPLANATION OF PLATE 57

Magnifications approximate.

FIGS. *1*—*Bulimina aspera* Cushman and Parker. Lateral view of hypotype, I.P.Co. well 1755, 2130 feet depth, ×25. (p. 349)

2—*Bulimina reussi* Morrow. Lateral view of hypotype, I.P.Co. well 2616, 1770 feet depth ×45, "*Clavulina*" shale. (p. 350)

3—*Neobulimina* sp. aff. *N. canadensis* Cushman and Wickenden. Lateral view of hypotype, I.P.Co. well 2616, 1770 feet depth, ×45, "*Clavulina*" shale. (p. 350)

4—*Ellipsonodosaria alexanderi* Cushman var. *impensia* Cushman. Lateral view of hypotype I.P.Co. well 1755, 2310 feet depth, ×35. (p. 350)

5a–c—*Discorbis huascari* Frizzell, n. sp. Holotype, I.P.Co. well 2174, 2720 feet depth, ×30. *a*, dorsal view; *b*, peripheral view; *c*, ventral view. (p. 350)

6a–c—*Gyroidina nitida* (Reuss). Hypotype, I.P.Co. well 1755, 2910 feet depth, ×30. *a*, dorsal view; *b*, peripheral view; *c*, ventral view. (p. 351)

7a–c—*Eponides huaynai* Frizzell, n. sp. Holotype, I.P.Co. well 3013, 2469 feet depth, ×40. *a*, dorsal view, *b*, peripheral view, *c*, ventral view. (p. 351)

8a–c—*Eponides zaratei* Frizzell, n. sp. Holotype, I.P.Co. well 2174, 2720 feet depth, ×40. *a*, dorsal view; *b*, peripheral view (inverted during preparation of plate); *c*, ventral view. (p. 351)

9a, b—*Rotalia* sp. cf. *R. beccariiformis* White. Hypotype, I.P.Co. well 2616, 1850 feet depth, ×60. *a*, dorsal view; *b*, peripheral view, *c*, ventral view, "*Clavulina*" shale. (p. 351)

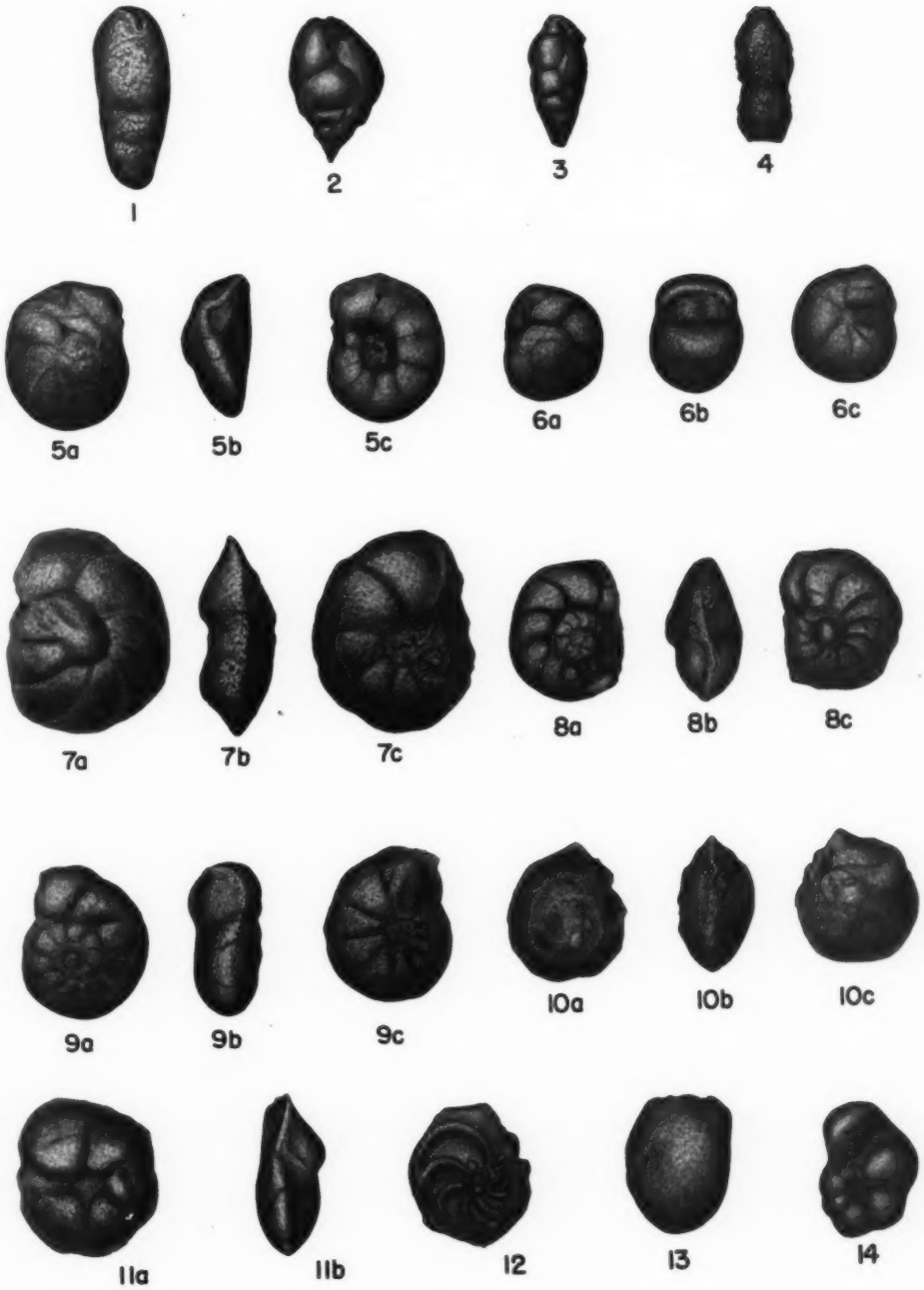
10a–c—*Epistomina* sp. cf. *E. stelligera* (Reuss). Hypotype, I.P.Co. well 2174, 3040 feet depth, ×35. *a*, dorsal view; *b*, peripheral view; *c*, ventral view. (p. 351)

11a, b—*Eponides* sp. cf. *E. huaynai*. Hypotype, I.P.Co. well 1755, 2150 feet depth, ×30. *a*, ventral view; *b*, peripheral view. (p. 351)

12—*Pulvinulinella*? sp. Dorsal view of hypotype, I.P.Co. well 1755, 2920 feet depth, ×30. (p. 352)

13—*Chilostomelloides*? sp. Lateral view of hypotype, I.P.Co. well 1755, 3040 feet depth, ×25. (p. 352)

14—*Globigerina* sp. cf. *G. cretacea* d'Orbigny. Ventral view of hypotype, I.P.Co. well 2616, 1750 feet depth, ×40, "*Clavulina*" shale. (p. 352)



Frizzell, Cretaceous Foraminifera

Interesting evidence for the lagenid origin of the genus *Pseudoglandulina* is offered by *P. marginuliniformis*. In this species, specimens are not uncommon which show a marginulinoid initial coil, but in every other respect agree with other members of the genus. A similar ontogeny, if correctly interpreted in the description and figure, is shown by "*Psecadium aduncum* (Costa)" from the probable Tamesi Cretaceous of Mexico (Galloway and Morrey, 1931, p. 336, pl. 37, fig. 13). This form is similar to the more inflated forms of *Pseudoglandulina*, but is characterized by an initial coil like that of *Marginulina*. Silvestri (1903, p. 212, text-figs. 3a–c) figured the exterior and section of a form, "*Glandulina*" *laevigata* (d'Orb.) var. *dentalinoides* Silvestri, showing a rudimentary initial whorl. This species, from the figures, appears to belong to the genus *Pseudoglandulina*.

If one may assume that the evolutionary history of a genus is to any degree recapitulated in the ontogeny of specimens of its commonest species, the initial coil in *P. marginuliniformis*, and perhaps in *P.? "aduncum"* and *P.? dentalinoides*, would seem to indicate that *Pseudoglandulina* is definitely lagenid in origin, and that it probably descended directly from the earlier members of the genus *Marginulina*.

PSEUDOGLANDULINA sp. cf. P. INFLATA (Bornemann)
Plate 56, figure 18

?*Glandulina inflata* BORNEMANN, *1855*, Deutsche geol. Gesell. Zeitschr., vol. 7, p. 320, pl. 12, figs. 6–7.

Test small, obovoid, consisting of a linear series of greatly overlapping chambers; chambers 4 in number, initial chamber pointed, last chamber about two-thirds length of test; sutures finely incised, straight; wall smooth, unornamented; aperture terminal, subcentral, circular, radiate, not produced.

Dimensions of hypotype, from I.P.Co. well 1755, 2540 feet depth: height, 0.49 mm.; diameter, 0.34 mm.

A single specimen from the Mal Paso shale tentatively is referred to this Oligocene species. More material possibly will show the Peruvian form to belong to a distinct species.

PSEUDOGLANDULINA MARGINULINIFORMIS Frizzell, n. sp.
Plate 56, figures 20, 21a, b

Test medium small, obovoid to elliptical in outline, megalospheric form a linear series of moderately overlapping chambers, an initial coil in microspheric form; chambers 4 to 6 in megalospheric form and in linear portion of microspheric form, slightly inflated, about 4 chambers in initial coil of microspheric form, penultimate chambers with width about 2½ times height; sutures slightly impressed, straight; wall smooth, unornamented; aperture terminal, central, circular, radiate, moderately produced.

Dimensions of holotype, from I.P.Co. well 2841, 2915 feet depth: height, 0.99 mm.; diameter, 0.43 mm.

Dimensions of paratype, from I.P.Co. well 2000, 2315 feet depth: height, 0.59 mm.; diameter, 0.32 mm.

Eight specimens have been examined from the Mal Paso shale. *P. marginuliniformis* seems to be distinctive, and unlike any of the more closely related species in the frequent possession of a coiled initial portion. This species is somewhat similar to *P. manifesta* (Reuss) (1851, p. 6, pl. 1, fig. 4, as *Glandulina*), but is relatively less elongated, uniformly larger, and has narrower visible and less inflated chambers, and less impressed sutures. The initial coil is similar to that figured for certain more inflated species.

Genus VAGINULINA d'Orbigny, 1826
VAGINULINA sp. A
Plate 56, figure 22

Test medium large, very slender, much compressed, slightly tapering except at septal face, sides nearly straight, rectangular in cross section; chambers very narrow and high, very broadly arched; sutures high, probably due to erosion of specimen; wall ornamented only with raised sutures; aperture not visible on specimen.

Dimensions of specimens (broken), from I.P.Co. well 1755, 3020 feet depth: height, 1.02 mm.; width, 0.40 mm.; thickness, 0.19 mm.

The single specimen encountered in the Mal Paso shale somewhat resembles *V. texana* Cushman (1930, p. 30, pl. 4, figs. 2, 3), but probably is distinct. It is likely

that this form should be referred to a different genus, but detailed consideration of the classification of vaginulinoid forms is needed before any revision can be made.

VAGINULINA sp. B
Plate 56, figure 23

Test medium large, slender, moderately compressed, dorsal margin apparently slightly concave, ventral margin very slightly crenate; width of chambers about 3 times height; sutures oblique, descending in broad arc to ventral margin, raised, thickened at center to form elongate nodes; wall smooth, ornamented only by the sutural nodes; aperture not visible on specimen.

Dimensions of specimen (broken), from I.P.Co. well 2841, 2915 feet depth: height, 0.74 mm.; width, 0.47 mm.; thickness, 0.26 mm.

A single specimen from the Mal Paso shale belongs to the same group as *V. cretacea* Plummer (1927, p. 172, pl. 2, fig. 8, as a variety of *V. gracilis*), but has much narrower sutural nodes. It is narrower and has narrower sutural nodes than *V. taylorana* Cushman (1938, p. 36, pl. 5, fig. 19).

Genus FRONDICULARIA Defrance, 1826
FRONDICULARIA sp.
Plate 56, figure 24

Two broken specimens from the Mal Paso shale are somewhat like forms which have been referred to *F. cordai* Reuss (1844, p. 302; 1845, p. 31, pl. 8, figs. 26–28, pl. 13, fig. 41) and *F. cordata* Roemer (1841, p. 96, pl. 15, fig. 8). They resemble *F. goldfussi* Reuss (1860, p. 192, pl. 4, fig. 7), but that species does not have the proloculum surrounded by later chambers as do the Peruvian specimens.

Subfamily LAGENINAE
Genus LAGENA Walker and Jacob, 1798
LAGENA HEXAGONA (Williamson)
Plate 56, figure 26

Entosolenia squamosa (Montagu) var. γ, *hexagona* WILLIAMSON, *1848*, Annals and Mag. Nat. History, ser. 2, vol. 1, p. 20, pl. 2, fig. 23.
Lagena hexagona (Williamson). CUSHMAN, *1913*, U. S. Nat. Mus. Bull. 71, p. 17, pl. 6, figs. 2–3; *1931*, Tennessee Geol. Survey, Bull. 41, p. 38, pl. 5, fig. 12.

Test small, subspherical, consisting of a single chamber; wall ornamented with fine raised lines, forming an irregular closely reticulated pattern; aperture on produced neck (broken flush with chamber on specimen).

Dimensions of hypotype, from I.P.Co. well 1755, 3000 feet depth: height, 0.32 mm.; diameter, 0.29 mm.

A single specimen from the Mal Paso shale agrees closely with Recent and Cretaceous specimens examined.

LAGENA? MALPASOENSIS Frizzell, n. sp.
Plate 56, figure 25

Test small, subspherical, consisting of a single chamber, with a very small, sharp projection at base; surface smooth, unornamented; aperture terminal, small, circular, radiate, slightly produced.

Dimensions of holotype, from subsurface occurrence in general vicinity of Negritos, Peru: height, 0.46 mm.; diameter, 0.39 mm.

Lagena? malpasoensis appears to belong to the group of *L. apiculata* (Reuss) (1851, p. 22, pl. 2, fig. 1, as *Oölina*), from the Upper Cretaceous of Poland, but is distinguished from that species by being subspherical rather than ovoid. It most nearly resembles *L. urnula* Franke (1936, p. 90, pl. 9, fig. 6) from the Lias of Germany, but is subspherical rather than obovate. *L. simplex* (Reuss) (1851, p. 22, pl. 2, figs. 2a–b, as *Oölina*) is similar, but more nearly ovate and lacks the rudimentary basal spine.

Apparently similar forms have been figured as *Glandulina cubensis* Cushman and Bermudez (1937, p. 12, pl. 1, fig. 42) and "*G.*" *globulus* Reuss (1863, vol. 48, pt. 1, p. 66, pl. 8, figs. 94–95). In the absence of material to section, possible identity with these species, as well as definite determination of the genus, has been impossible.

Family POLYMORPHINIDAE
Subfamily POLYMORPHININAE
Genus GLOBULINA d'Orbigny, 1839
GLOBULINA LACRIMA (Reuss)
Plate 56, figure 27

Polymorphina (*Globulina*) *lacrima* REUSS, *1845*, Verstein. böhm. Kreide., p. 40, pl. 12, fig. 6, pl. 13, fig. 83.
Globulina lacrima (Reuss) CUSHMAN and OZAWA, *1930*, U. S. Nat. Mus. Proc., vol. 77, art. 6, pp. 77–78.

The name *Globulina lacrima* has been

applied to pyriform and ovoid specimens of Cretaceous age, and includes a large number of forms often referred to *G. gibba* (d'Orbigny). A few specimens from the Mal Paso shale agree in every visible respect with specimens from the later Cretaceous of the United States. The species occurs in the Tamesí formation of Mexico, and in the Upper Cretaceous of Trinidad.

Dimensions of hypotype, from I.P.Co. well 1755, 2900 feet depth: height, 0.66 mm.; diameter, 0.52 mm.

Family HETEROHELICIDAE
Subfamily EOUVIGERININAE
Genus SIPHOGENERINOIDES
Cushman, 1927

Dietrich (1935, pp. 80–81, text-figs. 1–3) proposed *Orthokarstenia* as a new genus, with the monotypic genotype *O. ewaldi* (Karsten) (1858, p. 114, pl. 6, figs. 3a–c, as *Orthocerina*). Cushman (1929, pp. 58–59), however, had already recognized that "*Orthocerina*" *ewaldi* belongs to the genus *Siphogenerinoides*, suggesting that specimens of that species were casts. Later, Cushman and Hedberg (1930, p. 68, pl. 9, figs. 10–12) figured a wax mold of a specimen of *S. ewaldi*, not only demonstrating the generic position of the species, but indicating as well its specific characters. It is evident, then, that *Orthokarstenia* Dietrich, 1935, must be regarded as a synonym of *Siphogenerinoides* Cushman, 1927.

SIPHOGENERINOIDES CRETACEA Cushman
Plate 56, figure 28

Siphogenerinoides cretacea CUSHMAN, *1929*, Cushman Lab. Foram. Research Contr., vol. 5, pt. 3, p. 58, pl. 9, figs. 14–15.

Rare specimens from the "*Clavulina* shale" have been compared with the holotype of *S. cretacea* and, although rather poorly preserved, seem to belong to that species.

Dimensions of hypotype, from I.P.Co. well 2616, 1850 feet depth: height, 1.68 mm.; diameter, 0.57 mm.

SIPHOGENERINOIDES PLUMMERI
COYA Frizzell, n. var.
Plate 56, figure 29

Test small, elongate, 4 to 4½ times as long as wide, slightly tapering to last chamber, early chambers biserial, later chambers uniserial, circular in cross section; chambers somewhat indistinct, very slightly inflated; sutures indistinct, very slightly depressed; surface ornamented by about 8 longitudinal costae, sharp, traversing sutures without change, ending abruptly at a raised thread surrounding septal face; aperture broadly elliptical, with a very short neck.

Dimensions of holotype, from I.P.Co. well 3040, 1945 feet depth: height, 0.73 mm.; diameter, 0.22 mm.

Two specimens have been found in the Mal Paso shale that apparently are closely related to the typical form of *Siphogenerinoides plummeri* (Cushman) (1926a, as *Siphogenerina*). They differ in lacking the spinose angles at the intersection of the costae with the sutures, and in the presence of a raised thread bounding the septal face on the last chamber.

As in the case of *Marginulina coya*, the varietal name is a noun in apposition.

SIPHOGENERINOIDES CLARKI Cushman
and Campbell
Plate 56, figure 30

Siphogenerinoides clarki CUSHMAN and CAMPBELL, *1936*, Cushman Lab. Foram. Research Contr., vol. 12, pt. 4, p. 91, pl. 13, figs. 9–12.

Three specimens were found of an extremely poorly preserved but distinctive species of *Siphogenerinoides*. These "*Clavulina* shale" forms resemble the microspheric generation of *S. clarki* from the uppermost Cretaceous of California, particularly in the constriction in the test following the biserial portion.

Dimensions of hypotype, from I.P.Co. well 2616, 1790 feet depth: height, 0.76 mm.; diameter, 0.29 mm.

Family BULIMINIDAE
Subfamily BULIMININAE
Genus BULIMINA d'Orbigny, 1826
BULIMINA ASPERA Cushman and Parker
Plate 57, figure 1

Bulimina aspera CUSHMAN and PARKER, *1940*, Cushman Lab. Foram. Research Contr., vol. 16, pt. 2, pp. 44–45, pl. 18, figs. 18–19.

Test of medium size, obovoid, length about three times width, consisting of 5 whorls, initial end bluntly pointed; chambers slightly inflated, joined at an angle of about 90°; sutures distinct, slightly de-

pressed; wall smooth, perforate; aperture elongate, at apex of test.

Dimensions of hypotype, from I.P.Co. well 1755, 2130 feet depth: height, 0.94 mm.; diameter, 0.42 mm.

Forms apparently identical with *Bulimina aspera* are rare in the Mal Paso shale.

BULIMINA REUSSI Morrow
Plate 57, figure 2

Bulimina ovulum REUSS, *1845*, Verstein. böhm. Kreide., pt. 1, pl. 8, fig. 57, pl. 13, fig. 73 (not *B. ovula* d'Orbigny, 1839).

Bulimina reussi MORROW, *1934*, Jour. Paleontology, vol. 8, p. 195, pl. 29, fig. 12. CUSHMAN and PARKER, *1935*, Cushman Lab. Foram. Research Contr., vol. 11, p. 99, pl. 15, figs. 8a–b.

Test small, length about 1½ times width, tapering; chambers numerous, slightly inflated, about 6 whorls, last whorl constituting half of test; sutures moderately impressed; wall smooth, perforate; aperture small, at apex of test.

Dimensions of hypotype, from I.P.Co. well 2616, 1770 feet depth: height, 0.44 mm.; width, 0.29 mm.

This species has been established as a Mal Paso form but occurs abundantly in the "*Clavulina* shale" of well 2616.

Genus NEOBULIMINA Cushman and Wickenden, 1928

NEOBULIMINA sp. aff. N. CANADENSIS Cushman and Wickenden
Plate 57, figure 3

?Neobulimina canadensis CUSHMAN and WICKENDEN, *1928*, Cushman Lab. Foram. Research Contr., vol. 4, pt. 1, p. 13, pl. 1, figs. 1–2.

Test small, elongate, inverted lanceolate in outline, triserial except for biserial last whorl; chambers numerous, increasing gradually in size, moderately inflated, in about 5 whorls; sutures impressed; wall smooth, unornamented; aperture at apex of test, long, narrow.

Dimensions of hypotype, from I.P.Co. well 2616, 1770 feet depth: height, 0.42 mm.; width, 0.20 mm.

Moderately rare specimens from the "*Clavulina* shale" of well 2616 are referred tentatively to this species, although the Peruvian form may be specifically distinct. Better preserved material is needed, however, before this species can be identified with certainty.

Family ELLIPSOIDINIDAE
Genus ELLIPSONODOSARIA Silvestri, 1900

ELLIPSONODOSARIA ALEXANDERI IMPENSIA Cushman
Plate 57, figure 4

Ellipsonodosaria alexanderi var. *impensia* CUSHMAN, *1938*, Cushman Lab. Foram. Research Contr., vol. 14, p. 48, pl. 8, figs. 4–5.

Test small, elongate, slightly tapering, chambers moderately inflated, circular in cross section, height slightly less than twice width; sutures impressed, straight; wall ornamented with very numerous, irregularly placed tubercles; aperture terminal, central, produced, subelliptical.

Dimensions of hypotype (broken specimen), from I.P.Co. well 1755, 2310 feet depth: height, 0.49 mm.; diameter, 0.23 mm.

Three broken specimens are very close to this variety and tentatively are referred to it.

Family ROTALIIDAE
Subfamily DISCORBINAE
Genus DISCORBIS Lamarck, 1804

DISCORBIS HUASCARI Frizzell, n. sp.
Plate 57, figures 5a–c

Test of medium size, planoconvex, high, dorsal side convex, ventral side nearly flat with a shallow umbilicus; chambers numerous, 3 whorls visible on dorsal side, earlier chambers covered with calcareous material, a single whorl visible on ventral side, about 7 chambers in last whorl; sutures slightly recurved on dorsal side, nearly straight on ventral, slightly impressed; wall smooth.

Dimensions of holotype, from I.P.Co. well 2174, 2720 feet depth: height, 0.34 mm.; diameter, 0.66 mm.

This form seems to be most closely related to "*Discorbis turbo* d'Orbigny" (Chapman, 1896, p. 591, pl. 13, figs. 13a–b). Specimens examined from the Gault of England tentatively identified with "*D. turbo*" differ from the Peruvian specimens in having fewer chambers and raised sutures, and in being more nearly concentric. It is likely that the typical form (*Rotalia turbo* d'Orbigny 1826, p. 274, modèle 73), is distinct from both the Gault and the Mal Paso forms. *Discorbis huascari* is larger, lower, and less nearly concentric than the specimens referred to *Eponides haidingerii* (d'Orbigny) (Cushman, 1931, p. 54, pl. 8, figs. 15–16).

This species is named for the heir to the Inca dynasty, son of Huayna Capac, executed by Atahuallpa prior to the conquest of Peru

Genus GYROIDINA d'Orbigny, 1826
GYROIDINA NITIDA (Reuss)
Plate 57, figures 6a–c

Rotalina nitida, (Reuss) *1844*, Geog. Skizze Böhmen, vol. 2, pt. 1, p. 214; *1845–1846*, Verstein. böhm. Kreide., pt. 1, p. 35, pl. 8, fig. 52, pl. 12, figs. 8, 20.
Gyroidina nitida. CUSHMAN and JARVIS, *1932*, U. S. Nat. Mus. Proc., vol. 80, art. 14, p. 47, pl. 14, figs. 2a–c.

Test of medium size, trochoid, spire very low, periphery very broadly and evenly rounded, outline nearly circular in dorsal view, broadly ovate in lateral view, ventral side not umbilicate; chambers indistinct; sutures very finely incised, flush with surface; wall smooth and unornamented; aperture not visible on specimens.

Dimensions of hypotype, from I.P.Co. well 1755, 2910 feet depth: height, 0.44 mm.; diameter, 0.53 mm.

This species is quite rare in the Mal Paso shale. The Peruvian examples agree closely with specimens from the uppermost Cretaceous shale of Lizard Springs, Trinidad.

Subfamily ROTALIINAE
Genus EPONIDES Montfort, 1808
EPONIDES HUAYNAI Frizzell, n. sp.
Plate 57, figures 7a–c

Test medium large, trochoid, consisting of about 2½ whorls, spire low, outline elliptical in dorsal view, periphery with very low keel, outline roughly lenticular in peripheral view; with large shallow umbilicus on ventral side; chambers large, nearly flat dorsally, moderately inflated below; sutures incised, nearly flush with surface; wall smooth and unornamented; aperture a low slit at base of sutural face, near ventral side.

Dimensions of holotype, from I.P.Co. well 3013, 2469 feet depth: height, 0.30 mm.; diameter, 0.72 mm.

This species is somewhat similar to *E. umbonella* (Reuss) as figured by Cushman and Church (1929, p. 515, pl. 40, figs. 7–9). The specific name is derived from that of Huayna Capac, Inca ruler preceding Atahuallpa.

EPONIDES sp. cf. E. HUAYNAI
Plate 57, figures 11a, b

The form figured is similar in outline and sculpture to the preceding species, and may be identical. It has fewer chambers, however, and less strongly recurved sutures, and therefore tentatively is separated.

Dimensions of hypotype, from I.P.Co. well 1755, 2150 feet depth: height, 0.32 mm.; diameter, 0.74 mm.

EPONIDES ZARATEI Frizzell, n. sp.
Plate 57, figures 8a–c

Test of medium size, trochoid, nearly circular in outline in dorsal view, lenticular in peripheral view, of about 2½ whorls, earlier whorls covered with transparent calcareous material, with a protuberant clear ventral plug; chambers numerous; sutures limbate, flush with surface, recurved; wall smooth, ornamented only with ventral boss and dorsal thickening.

Dimensions of holotype, from I.P.Co. well 2174, 2720 feet depth: height, 0.22 mm.; diameter, 0.46 mm.

This species is much like *E. huaynai*, but is distinguished by the more numerous chambers, the ventral plug, limbate sutures, more nearly circular outline, and lenticular section.

The specific name given is in honor of A. de Zarate, historian of the Peruvian Conquest.

Genus ROTALIA Lamarck, 1804
ROTALIA sp. cf. R. BECCARIIFORMIS White
Plate 57, figures 9a–c

?Rotalia beccariiformis WHITE, *1928*, Jour. Paleontology, vol. 2, p. 287, pl. 39, figs. 2a–c.

A single specimen, belonging apparently to the group of *R. beccarii* (Linné), has been referred tentatively to this species described from the Upper Cretaceous of Mexico.

Dimensions of hypotype, from the "*Clavulina* shale" of well 2616, 1850 feet depth: height, 0.19 mm.; diameter, 0.37 mm.

Subfamily SIPHONININAE
Genus EPISTOMINA Terquem, 1883
EPISTOMINA sp. cf. E. STELLIGERA (Reuss)
Plate 57, figures 10a–c

?Rotalina stelligera REUSS, *1854*, Akad. Wiss. Wien, Math.-naturwiss. Kl., Denkschr., vol. 7, p. 69, pl. 25, fig. 15.

This unique specimen from Peru has been

compared with specimens of Reuss's species from the Gault of England. Relationship is obvious, but the preservation of the Mal Paso specimen precludes any possibility of exact identification.

Dimensions of hypotype, from I.P.Co. well 2174, 3040 feet depth: height, 0.30 mm.; diameter, 0.47 mm.

Family CASSIDULINIDAE
Subfamily CERATOBULIMININAE
Genus PULVINULINELLA Cushman, 1926
PULVINULINELLA? sp.
Plate 57, figure 12

Specimens somewhat resembling forms referred to the genus *Pulvinulinella* occur rarely in the Mal Paso shale. The generally poor preservation of these forms, however, has made it impossible to attempt any certain identification.

Dimensions of specimen, from I.P.Co. well 1755, 2920 feet depth: height, 0.29 mm.; diameter, 0.69 mm.

Family CHILOSTOMELLIDAE
Subfamily CHILOSTOMELLINAE
Genus CHILOSTOMELLOIDES Cushman, 1926
CHILOSTOMELLOIDES? species
Plate 57, figure 13

A single poorly preserved specimen has been found, belonging apparently to the genus *Chilostomelloides*.

Dimensions of specimen, from I.P.Co. well 1755, 3040 feet depth: height, 0.72 mm.; width, 0.54 mm.; thickness, 0.47 mm.

Family GLOBIGERINIDAE
Genus GLOBIGERINA d'Orbigny, 1826
GLOBIGERINA sp. cf. G. CRETACEA d'Orbigny
Plate 57, figure 14

?Globigerina cretacea D'ORBIGNY, *1840*, Soc. géol. France, Mém., p. 34, pl. 3, figs. 12–14.

A number of very poorly preserved specimens belonging to the general group of *G. cretacea* have been encountered in the "*Clavulina* shale." Their preservation prevents more accurate identification.

Dimensions of hypotype, from I.P.Co. well 2616, 1750 feet depth: height, 0.22 mm.; diameter 0.47 mm.

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PLEISTOCENE AND PLIOCENE OSTRACODA OF THE COASTAL REGION OF SOUTHERN CALIFORNIA

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ABSTRACT—As a contribution to the knowledge of Quaternary and late Tertiary Ostracoda of the coastal region of southern California, 25 new species and two varieties are described in this paper. A check list is presented showing the distribution of these forms from 18 widely distributed localities. Twelve of the recorded species were noted living today in marine environs along the Pacific coast.

No attempt has been made in this study to indicate the ecological and chronological values of the recorded species because of inadequate stratigraphical and areal control.

It is hoped that this work will stimulate further interest in the study of Tertiary Ostracoda of California.

INTRODUCTION

ALTHOUGH the ostracodes have long been recognized by microscopists as occupying a major biotope in the paleontological realm of California, the group has received but little attention as to its applicability to economic and academic paleostratigraphic problems. This negligence has been due primarily to the important role played by the Foraminifera in the petroleum industry. Thus, as an introduction to the study of the ostracodes of this region, the present investigation has been to systematically describe and to illustrate the common forms in marine Pleistocene and Pliocene deposits of the coastal area of southern California and to give some concept of their areal distribution. No attempt has been made to evaluate the ecologic and chronologic potentials of the species. Before this can be done additional knowledge must be assembled on Recent faunas and further detailed investigations of horizontal and vertical distribution of the species are required.

This paper, containing the first information to be published on California fossil ostracodes since Chapman (1896) described a group of brackish water cypridine forms from Pliocene deposits near Berkeley, California, records 26 species and two varieties. With the exception of one form (*Cythereis glauca* Skogsberg), all are considered new. The group is represented by the following genera: *Cytherelloidea*, *Bythocypris*, *Bairdia*, *Paracypris*, *Cytheridea*, *Loxoconcha*, *Para-*

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EXPLANATION OF PLATE 58

FIGS. *1–4—Archicythereis holmani* Le Roy, n. sp. ×37. Holotype, no. 6810. *1*, exterior view of right valve; *2*, interior view of right valve; *3*, exterior view of left valve; *4*, interior view of left valve. (p. 371)

5–8—Archicythereis newportensis Le Roy, n. sp. ×41. Cotypes. *5*, exterior view of right valve; *6*, interior view of right valve; no. 6813. *7*, exterior view of left valve; *8*, interior view of left valve, no. 6812. (p. 372)

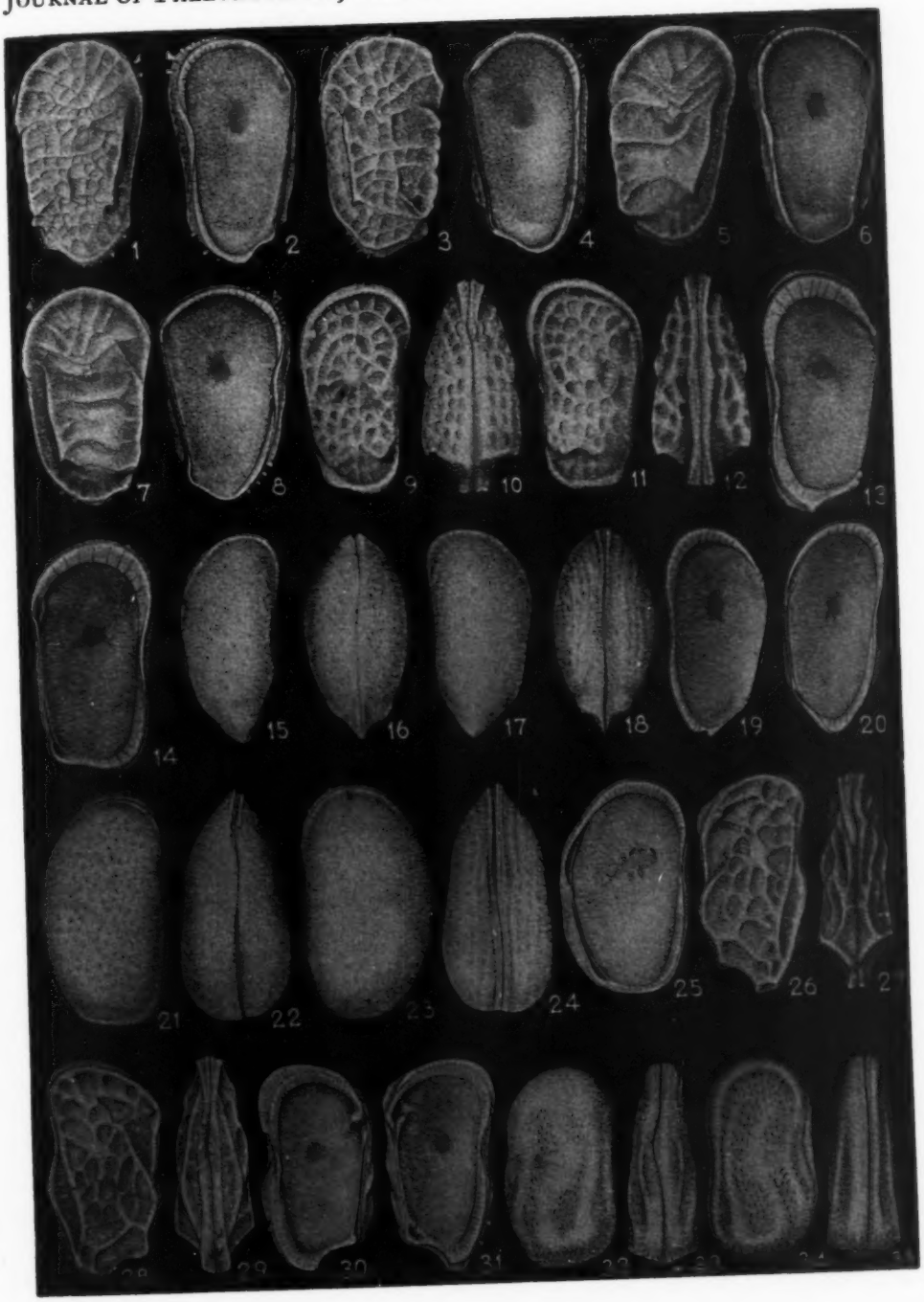
9–14—Cythereis schencki Le Roy, n. sp. ×55. Holotype, figs. 9–12, no. 6832. Paratype, figs. 13 14, no. 6833. *9*, right valve; *10*, dorsal view; *11*, left valve; *12*, ventral view; *13*, interior view of right valve; *14*, interior view of left valve. (p. 371)

15–20—Cytheridea? pedroensis Le Roy, n. sp. ×43. Holotype, figs. 15–18, no. 6826. Paratype, figs. 19, 20, no. 6827. *15*, right valve; *16*, dorsal view; *17*, left valve; *18*, ventral view; *19*, interior view of right valve; *20*, interior view of left valve. (p. 359)

21–25—Cytheridea beaconensis Le Roy, n. sp. ×35. Holotype, figs. 21–24, no. 6830. Paratype, fig. 25, no. 6831. *21*, right valve; *22*, dorsal view; *23*, left valve; *24*, ventral view; *25*, interior view of left valve. (p. 359)

26–31—Cythereis diegoensis Le Roy, n. sp. ×41. Holotype, figs. 26–29, no. 6804. Paratype, figs. 30, 31, no. 6805. *26*, right valve; *27*, dorsal view; *28*, left valve; *29*, ventral view; *30, 31*, inside view of both valves. (p. 369)

32–35—Cytherelloidea californica Le Roy, n. sp. ×34. Holotype, no. 6835. *32*, right valve; *33*, dorsal view; *34*, left valve; *35*, ventral view. (p. 357)



LeRoy, Pleistocene and Pliocene Ostracoda

cytheridea, Cytheropteron, Brachycythere, Hemicythere, Basslerites, Cythereis, Pyricythereis, Archicythereis, Leguminocythereis and *Caudites.*

Cythereis, Brachycythere and *Hemicythere* are most commonly encountered.

To obtain some concept of the relationship of the described species to living forms, preliminary studies were made of Recent assemblages from Avalon Bay, Monterey Bay and Sunset Beach Lagoons. Of the 28 species recorded, the following were found to be living today in marine environs along the Pacific Coast: *Bairdia verdesensis, Brachycythere lincolnensis, Caudites fragilis, Cythereis glauca, Cytheridea beaconensis, Cytherelloidea californica, Hemicythere jollaensis, Hemicythere? californiensis, Hemicythere? californiensis* var. *hispida, Loxoconcha lenticulata,* and *Paracypris pacificus.*

It is of interest to note that the widely distributed species *Brachycythere driveri, Cythereis kewi, C. pennata, C. diegoensis, Pyricythereis simiensis, Paracytheridea granti* and *Leguminocythereis corrugata* were not observed in recent assemblages.

Ostracodes are rare in the lower Pliocene and Miocene sediments of the Los Angeles and Ventura basins and only the species herein recorded were noted from this part of the section of these areas. Ostracodes from the Pliocene, Miocene, Oligocene and Eocene of the San Joaquin Valley of California are locally abundant but they show no affinity to the species listed in this paper.

The present investigation has led the author to believe that further comprehensive and systematic studies of the California Ostracoda would aid materially in the solution of biostratigraphic problems of the region.

I wish to express my appreciation to Mr. G. C. Gester, Chief Geologist, and to Dr. J. O. Nomland, Chief Geologist, Foreign Division of the Standard Oil Company of California, and to Mr. N. Hardy, manager of the Nederlandsche Pacific Petroleum Maatschappij for permission to publish the results of this investigation. I am sincerely grateful to Messrs. A. Hamid and Damin of the Nederlandsche Pacific Petroleum Maatschappij, Medan, Sumatra, for their careful and accurate drawing of all plates; to Mr. W. H. Holman of the Standard Oil Company of California for material which forms the basis of this paper; to Mr. M. I. Natland of the Richfield Oil Company of California for recent material from the San Pedro Channel; to Dr. H. V. Howe, Professor of Geology, Louisiana State University, for his suggestions regarding several species; to Dr. H. G. Schenck of Stanford University for his criticism of the manuscript and aid in publication; to Mr. W. Barbat of the Standard Oil Company of California for submittal of Pliocene, Miocene, Oligocene and Eocene ostracode material from the San Joaquin Valley, California; and to Mr. C. H. Gin of the Nederlandsche Pacific Petroleum Maatschappij for his assistance during the preparation of the manuscript.

All holotypes, paratypes and cotypes figured and described in this paper have been deposited in the Stanford University Paleontological Collection, Stanford, California. Paratype specimens of most species are filed in the paleontological collections of the Standard Oil Company of California Laboratory, Los Angeles, California. A number of paratype and ideotype specimens have been deposited in the paleontological collections of the Colorado School of Mines, Golden, Colorado, also in the Cushman Paleontological Collections, Sharon, Massachusetts, and in the paleontological collections of the Nederlandsche Pacific Petroleum Maatschappij, Medan, Sumatra.

LOCALITIES

The deposits and localities from which the described species were collected lie between north latitudes 32° 45′ and 34° 50′ and west longitudes 117° and 120° 30′ and range from the coastline to 20 miles inland.

L-1 San Diego formation ("middle Pliocene"), Pacific Beach, La Jolla Quadrangle. San Diego County, California. Scaled 2 inches south and 0.80 inch west from the intersection of west longitude 117° 15′ and north latitude 32° 15′. Ostracodes abundant.

L-2 Las Pasas formation ("Pleistocene"). Sulphur Canyon, Piru Quadrangle, Ventura County, California. Scaled 5.10 inches north and 1.30 inches east from the southwest corner of the quadrangle. Ostracodes rare.

L-3 San Pedro formation ("Pleistocene"),

Beacon and Second Streets, City of San Pedro, Wilmington Quadrangle, Los Angeles County, California. Ostracodes common.

L-4 Santa Barbara formation ("upper Pliocene"). Base of exposure at bath house, Bath House Beach, City of Santa Barbara, Santa Barbara Quadrangle, Santa Barbara County, California. Scaled 3.20 inches east and 5.05 inches north from the southwest corner of quadrangle. Ostracodes common.

L-5 Terrace deposits ("Pleistocene"). Exposure on Lincoln Boulevard, near City of Venice, Venice Quadrangle, Los Angeles County, California. Scaled 6.20 inches south and 3.90 inches west from the northeast corner of quadrangle. Ostracodes rather rare.

L-6 Timms Point formation ("Pleistocene"). Deadman Island, Wilmington Quadrangle, Los Angeles County, California. Scaled 4.72 inches north and 4.60 inches east from the southeast corner of quadrangle. Ostracodes rather rare.

L-7 San Diego formation ("middle Pliocene"). Happy Camp Canyon, north side of Simi Valley, Piru Quadrangle, Ventura County, California. Scaled 6.20 inches north and 5.90 inches west from the southeast corner of quadrangle. Ostracodes rare.

L-8 Lomita formation ("Pleistocene"). Hilltop Quarry, Palos Verdes Hills, San Pedro Hills Quadrangle, Los Angeles County, California. Scaled 9.80 inches north and 0.50 inches west from the southeast corner of the quadrangle. Ostracodes rather common.

L-9 "Upper Pliocene." Locality: Holman

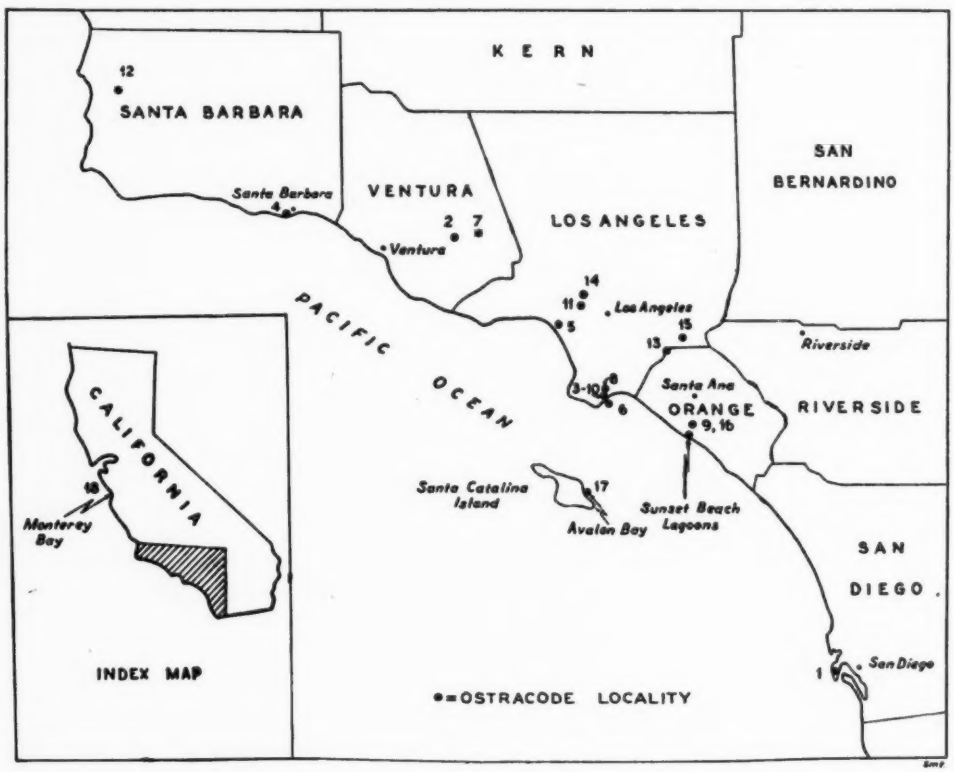


FIG. 1—Sketch map of the coastal region of southern California showing ostracode collecting localities.

9A, Newport Lagoon, Tustin Quadrangle, Orange County, California. Scaled 2.95 inches north and 1.08 inches east from the southwest corner of quadrangle. Ostracodes very common.

L-10 Lomita marl ("Pleistocene"). City of San Pedro. On Second Street, about 100 feet east of Pacific Avenue, Wilmington Quadrangle, Los Angeles County, California. Scaled 7.20 inches north and 2.05 inches east from southwest corner of quadrangle. Ostracodes rather common.

L-11 Pliocene. (Holman No. 36 locality, Baldwin Hills.) Near Standard Oil Company's Well, Vickers No. 2–10, Hollywood Quadrangle, Los Angeles County, California. Scaled 0.85 inch north and 2.65 inches east from the southwest corner of quadrangle. Ostracodes rare.

L-12 Foxen formation ("Pliocene"). *Elphidium* division of Canfield. (Bull. Am. Assoc. Petrol. Geologists, vol. 23, No. 1, 1939.) In railroad cut just north of Schumann, Guadalupe Quadrangle, Santa Barbara County, California. Scaled 4.30 inches south and 0.40 inch west from the northeast corner of quadrangle. Ostracodes rare.

L-13 Pliocene. Murphy Coyote Hills. At Standard Oil Company's Well, Emery No. 55, Anaheim Quadrangle, Los Angeles County, California. Scaled 6.70 inches south and 1.25 inches east from the northwest corner of quadrangle. Ostracodes rare.

L-14 Pliocene? (Holman 25B locality.) In west bank of Ballona Creek, 150 feet south of Pacific Electric Bridge, Hollywood Quadrangle, Los Angeles County, California. Scaled 4.80 inches north and 3.35 inches east from the southwest corner of quadrangle. Ostracodes rare.

L-15 Pliocene? Scaled 8.55 inches south and 4.25 inches east from the northwest corner of La Habra Quadrangle, Los Angeles County, California. Ostracodes rare.

L-16 San Diego formation ("middle Pliocene"). On east side of Newport Bay, along Palisades road, Newport Beach Quadrangle, Orange County, California. Scaled 7.80 inches north and 1.20 inches west from the southeast corner of quadrangle. Ostracodes common.

L-17 Recent. Avalon Bay, Santa Catalina Island. Collected by A. Clarke and M. I. Natland. Ostracodes common.

L-18 Recent. Mussel Rock, Monterey Bay, California. Intertidal. Collected by L. T. Martin, L.S.J.U. Loc. 1164. Ostracodes common.

Note: Workers interested in the described fauna may obtain almost all described species from localities L-1, L-3, L-4, L-5, L-9, L-10, and L-16.

SYSTEMATIC DESCRIPTIONS

Order OSTRACODA Latreille

Family CYTHERELLIDAE Sars

Genus CYTHERELLOIDEA Alexander

CYTHERELLOIDEA CALIFORNICA Le Roy, n. sp.

Plate 58, figures 32–35; text-figure 2b′

Carapace medium, elongate in side view, thickest posteriorly; right valve conspicuously larger, overlaps around almost entire periphery; dorsal margin slightly concave near middle; ventral margin broadly concave near middle; anterior end broadly, uniformly rounded; posterior end more or less truncate; low inner marginal rim on left valve begins near posterior dorsal angle, extends along dorsal margin, around anterior end, back along ventral border, terminates at posterior ventral angle; conspicuous, broad ridge beginning above anterior ventral angle inside marginal rim trends posteriorly with slight upcurve, to point just above posterior ventral angle where it turns sharply upward, loops around, continues forward bordering ventral margin of shallow subcentral pit area; right valve commonly without marginal rim around anterior extremity; surface very minutely punctate.

Type.—Holotype no. 6835; length, 0.82 mm.; height, 0.50 mm.; thickness, 0.33 mm.; locality L-10, Lomita marl ("Pleistocene").

Remarks.—This species is very rare as a fossil but several recent specimens have been dredged from Avalon Bay, Santa Catalina Island and in Monterey Bay. It is easily

identified by its surface ridge pattern and punctate surface.

Family CYPRIDAE Baird
Genus BYTHOCYPRIS Brady
BYTHOCYPRIS ELONGATA Le Roy, n. sp.
Plate 59, figures 13–16; text-figure 2a′

Carapace in side view elongate, length about two and one half times height, lenticular in dorsal view; dorsal outline broadly, uniformly arched; ventral margin broadly concave; anterior extremity somewhat more rounded than posterior, slightly more compressed; hinge simple.

Type.—Holotype no. 6829; length, 0.70 mm.; height, 0.30 mm.; thickness 0.25 mm.; locality L-10; Lomita marl ("Pleistocene").

Remarks.—This species is very rare.

Genus BAIRDIA McCoy
BAIRDIA VERDESENSIS Le Roy, n. sp.
Plate 60, figures 5-9; text-figures 2f′g′

Carapace in side view subtriangular, highest near middle; dorsal margin of left valve strongly arched, right valve semiangulate in outline; ventral margin flattened near middle; anterior end subangulate; posterior end bluntly pointed, denticulations on posterior ventral of left valve (best exhibited on paratype specimen fig. 8); surface smooth; inner margin at considerable distance from line of concrescence around anterior and posterior ends; hinge margin simple; muscle pattern series of closely grouped ovate scars (refer to pl. 4, fig. 37).

Types.—Holotype no. 6771 (figs. 5-7); length, 1.17 mm.; height, 0.77 mm.; thickness, 0.57 mm.; paratype no. 6772 (figs. 8, 9); length, 1.18 mm.; height, 0.75 mm., locality L-6, Timms Point formation ("Pleistocene").

Remarks.—This species is common in Avalon Bay, Santa Catalina Island, depth 8.5 m. The short, blunt denticulations on the posterior ventral portion of the left valve identifies this species.

Genus PARACYPRIS Sars
PARACYPRIS PACIFICUS Le Roy, n. sp.
Plate 61, figures 15–18; text-figure 2z

Carapace elongate in side view, lenticular in dorsal view, highest, thickest near middle; dorsal margin broadly arched; ventral margin faintly concave; anterior extremity broadly rounded; posterior extremity rather sharply pointed, may show tendency toward slight upturn; hinge simple; inner margin at considerable distance from line of concrescence at both anterior and posterior ends, coincides for short distance along ventral side near middle; surface smooth; radial pore canals few, simple, best developed anteriorly; for average arrangement of muscle scars see plate 60, figure 38.

Types.—Holotype no. 6769 (figs. 15–17); length, 1.10 mm.; height, 0.47 mm.; thickness, 0.35 mm.; paratype no. 6770 (fig. 18); length, 1.00 mm.; height, 0.43 mm.; locality L-6, basal part of Timms Point formation ("Pleistocene").

Remarks.—This species is common at its

EXPLANATION OF PLATE 59

FIGS. *1–6—Brachycythere lincolnensis schumannensis* Le Roy, n. sp. ×35. Holotype, figs. 1–4, no. 6819. Paratype, figs. 5, 6, no. 6820. *1*, right valve; *2*, dorsal view; *3*, left valve; *4*, ventral view; *5*, *6*, inside view showing hinge structure. (p. 364)

7–12—Leguminocythereis corrugata Le Roy, n. sp. ×35. Holotype, figs. 7–10, no. 6807. Paratype, figs. 11, 12, no. 6808. *7*, right valve; *8*, dorsal view; *9*, left valve; *10*, ventral view; *11*, *12*, inside view showing development of hinge. (p. 372)

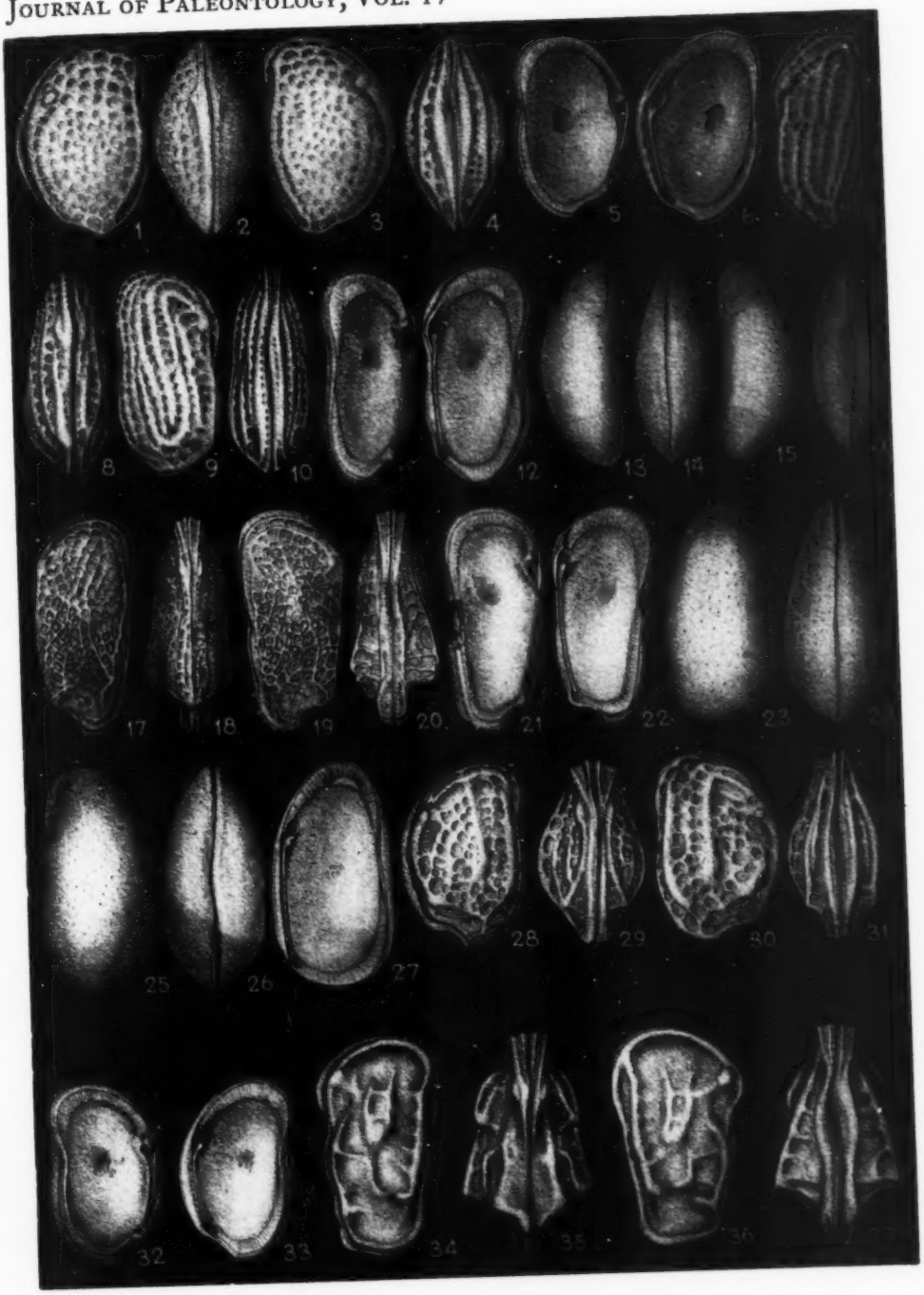
13–16—Bythocypris elongata Le Roy, n. sp. ×41. Holotype, no. 6829. *13*, right valve; *14*, dorsal view; *15*, left valve; *16*, ventral view. (p. 358)

17–22—Cythereis microreticulata Le Roy, n. sp. ×42. Holotype, figs. 17–20, no. 6823. Paratype, figs. 21, 22, no. 6824. *17*, right valve; *18*, dorsal view; *19*, left valve; *20*, ventral view; *21*, *22*, inside view showing hinge structure. (p. 370)

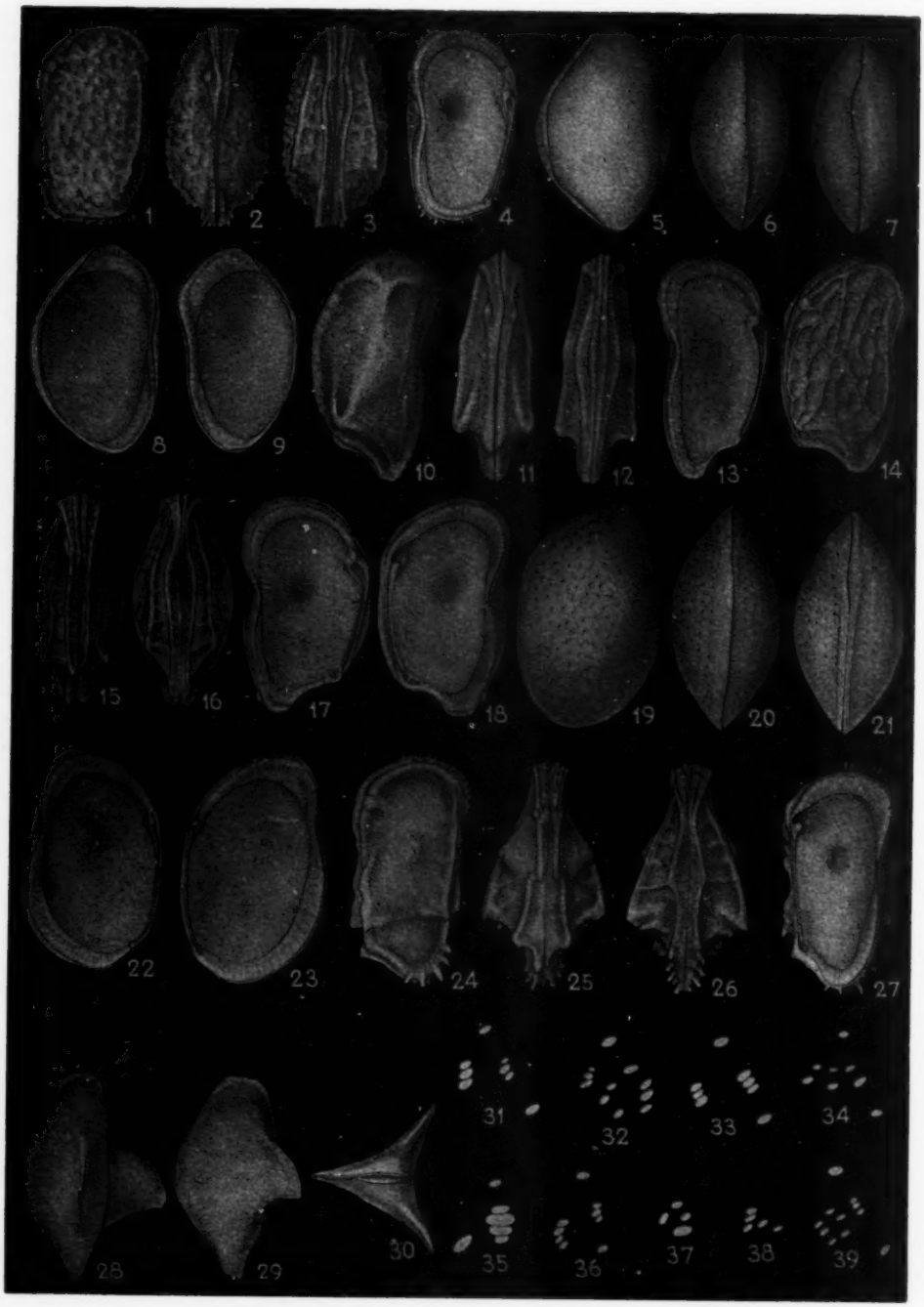
23–27—Basslerites delreyensis Le Roy, n. sp. ×56. Holotype, figs. 23–26, no. 6776. Paratype, fig. 27, no. 6777. *23*, right valve; *24*, dorsal view; *25*, left valve; *26*, ventral view; *27*, inside view of left valve. (p. 368)

28–33—Hemicythere jollaensis Le Roy, n. sp. ×28. Holotype, figs. 28–31, no. 6801. Paratype, figs. 32, 33, no. 6802. *28*, right valve; *29*, dorsal view; *30*, left valve; *31*, ventral view; *32*, *33*, inside view of valves showing hinge structure. (p. 365)

34–37—Cythereis pennata Le Roy, n. sp. ×34. Holotype, no. 6817. *34*, right valve; *35*, dorsal view; *36*, left valve; *37*, ventral view. (p. 370)



LeRoy, Pleistocene and Pliocene Ostracoda



LeRoy, Pleistocene and Pliocene Ostracoda

type locality where it is associated with *Brachycythere driveri, Hemicythere? californiensis, Loxoconcha lenticulata,* and *Bairdia verdesensis,* but its areal distribution appears to be restricted. It is abundant in recent sediments of Avalon Bay, Santa Catalina Island, at a depth of 8.5 meters.

This species resembles *Paracypris rosefieldensis* Howe and Law (1931, p. 30, pl. III, figs. 9–11) from the Vicksburg Oligocene of Louisiana.

Family CYTHERIDAE Baird

Genus CYTHERIDEA Bosquet

CYTHERIDEA BEACONENSIS Le Roy, n. sp.

Plate 58, figures 21–25; text-figure 2c′

Carapace elongate in side view, highest near middle, thickest posteriorly; dorsal margin gently, evenly arched; ventral margin slightly concave just anterior to middle; anterior end broadly, rather uniformly rounded; posterior end bluntly rounded; surface smooth, with numerous small pores; hinge margin of left valve consists of four elements: (1) elongate, moderately deep anterior socket opening anteriorly, having ten to twelve notches, (2) very short, sharp, smooth ridge lying just behind anterior socket, (3) narrow, shallow, finely crenulated groove lying behind ridge, (4) elongate posterior socket containing four notches; marginal areas moderately narrow; pore canals numerous, straight; details of muscle scar pattern not observed.

Types.—Holotype no. 6830 (figs. 21–24); length, 0.95 mm.; height, 0.55 mm.; thickness, 0.48 mm.; paratype no. 6831 (fig. 25); length, 0.90 mm.; height, 0.55 mm.; locality L-3, San Pedro formation ("Pleistocene").

Remarks.—This species occurs in recent lagoonal deposits at Sunset Beach, Orange County, California and Richardson's Bay, Tamalpais Quadrangle, California.

CYTHERIDEA? PEDROENSIS Le Roy, n. sp.

Plate 58, figures 15–20; text-figure 2t

Carapace medium, thin-walled, in side view subpyriform, highest anteriorly, thickest near middle; dorsal margin straight to weakly arched; ventral margin nearly straight, slightly concave just anterior to middle; posterior dorsal slope straight producing moderately distinct posterior dorsal angle; posterior extremity sharply pointed, apex just below middle; anterior extremity obliquely rounded; surface smooth, except for few, poorly developed pores; hinge of right valve consists of two elongate, notched dental areas, separated by finely crenulated marginal groove; components of left valve

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EXPLANATION OF PLATE 60

FIGS. *1–4—Hemicythere? californiensis hispida* Le Roy, n. var. ×29. Holotype, figs. 1–3, no. 68 5 Paratype, fig. 4, no. 6816. *1,* right valve; *2,* dorsal view; *3,* ventral view; *4,* interior view o right valve showing hinge structure. (p. 367

5–9—Bairdia verdesensis Le Roy, n. sp. ×24. Holotype, figs. 5–7, no. 6771. Paratype, figs. 8 9, no. 6772. *5,* right valve; *6,* dorsal view; *7,* ventral view; *8, 9,* inside view of left and right valves. (p. 358)

10–13—Caudites fragilis Le Roy, n. sp. ×60. Holotype, figs. 10–12, no. 6788. Paratype, *fig.* 13, no. 6789. *10,* right valve; *11,* dorsal view; *12,* ventral view; *13,* inside view of right valve. (p. 372)

14–18—Hemicythere palosensis Le Roy, n. sp. ×42. Holotype, figs. 14–16, no. 6786. Paratype, figs. 17, 18, no. 6787. *14,* right valve; *15,* dorsal view; *16,* ventral view; *17, 18,* interior views of right and left valves. (p. 365)

19–23—Loxoconcha lenticulata Le Roy, n. sp. ×42. Holotype, form B, female?, no. 6836.*19,* right valve; *20,* dorsal view; *21,* ventral view; *22, 23,* inside views of right and left valves. (p. 360)

24–27—Cythereis kewi Le Roy, n. sp. ×37. Holotype, figs. 24–26, no. 6797. Paratype, fig. 27, no. 6798. *24,* right valve; *25,* dorsal view; *26,* ventral view; *27,* inside view of left valve. (p. 369)

28–30—Cytheropteron minutum Le Roy, n. sp. ×37. Holotype, no. 6780. *28,* oblique view of right valve; *29,* right valve; *30,* posterior view. (p. 361)

31–39—Characteristic muscle scar patterns of left valves. These patterns show the normal arrangement. Minor variations in number and relative position of the individual scars occur. *31, Hemicythere? californiensis hispida* (p. 367); *32, Hemicythere? californiensis* (p. 366); *33, Brachycythere lincolnensis* (p. 367); *34, Hemicythere palosensis* (p. 365); *35, Basslerites delreyensis* (p. 364); *36, Brachycythere driveri* (p. 361); *37, Bairdia verdesensis* (p. 358); *38, Paracypris pacificus* (p. 358); *39, Hemicythere jollaensis* (p. 365).

opposite those of right valve; marginal areas narrow; pore canals straight, moderately spaced.

Types.—Holotype no. 6826 (figs. 15–18); length, 0.70 mm.; height, 0.35 mm.; thickness, 0.35 mm.; paratype no. 6827 (figs. 19, 20); length, 0.70 mm.; height, 0.38 mm. locality L-3, San Pedro formation ("Pleistocene").

Remarks.—This is a rare species. It is characterized by its pointed posterior extremity, its straight posterior dorsal slope, and its narrow marginal areas.

Genus LOXOCONCHA Sars
LOXOCONCHA LENTICULATA
Le Roy, n. sp.

Plate 60, figures 19–23; plate 61, figures 34–36; plate 62, figures 13, 14; text-figures 2f, g

Carapace thin shelled, subovate in side view, strongly lenticular in dorsal view, thickest near middle; dorsal margin straight to faintly curved; ventral margin broadly convex, with very strong anterior lip indentation; anterior end obliquely rounded;

DISTRIBUTION OF THE CALIFORNIA OSTRACODA

Species	Localities																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Archicythereis holmani									*C									
Archicythereis newportensis									*RC			VS			VS			
Bairdia verdesensis	*R		VS	VS		*S				RR							X	
Brachycythere driveri	S	S		*R		RR	S	VS		R	R					VS		
Brachycythere lincolnensis var. *schumannensis*												*R						
Brachycythere lincolnensis	R	S	S	S	*RS	VS		VS		RR						S	X	
Basslerites delreyensis					*RC								VS					
Bythocypris elongata										*S								
Caudites fragilis										*VS								X
Cythereis glauca	C	C	RC	VC	R	S	S			RC	RR			RR		RC	X	X
Cythereis diegonensis	*RR									S						VS		
Cythereis kewi	R			*R		VS			VS	RR	VS					S		
Cythereis microreticulata				*R					S									
Cythereis pennata	*R			S												S		
Cythereis schencki				*RC						RR								
Cytheridea ? pedroensis			*R															
Cytheridea beaconensis			*R														X	
Cytherelloidea californica				VS						*VS							X	X
Cytheropteron minutum															*S			
Hemicythere jollaensis	*R	S		S						VS	RR					S		X
Hemicythere palosensis										*R							X	X
Hemicythere ? californiensis	*C	C	RR	C	S	RC	S	S	S	RC	RC		R	RC	R	RC	X	
Hemicythere ? californiensis var. *hispida*				*S						S					R	RR	X	
Leguminocythereis corrugata	*R	R	S									VR	R			R		
Loxoconcha lenticulata			RC	RR		*S		R		C	S		S			S	X	X
Paracypris pacificus						*RR		S									X	
Paracytheridea grant	*RR			VS				VS								RC		
Pyricythereis simiensis							*R	VS	VC		VS	S			VS	VS		

S = Scarce; VS = Very scarce; R = Rare; RR = Rather rare; RC = Rather common; C = Common; VC = Very common; X = Present; * = type locality of species.

posterior end sharply rounded; surface smooth, minutely pitted; hinge margin of left valve shows several small anterior dental nodes, notched posterior socket and narrow crenulated edge corresponding to furrow of right valve; inner margin extends beyond the line of concrescence along the greater part of the ventral and anterior portions; radial pore canals distinct, moderately spaced; muscle pattern three or four closely spaced scars.

Types.—Holotype no. 6836 (pl. 4, figs. 19–23); length, 0.74 mm.; height, 0.47 mm.; thickness, 0.38 mm.; paratype no. 6774 (pl. 5, figs. 34–36); length, 0.78 mm.; height, 0.47 mm.; thickness, 0.38 mm.; locality L-6, Timms Point formation ("Pleistocene").

Remarks.—This species is widely distributed but generally not abundant. It occurs in recent material from Avalon Bay, Santa Catalina Island, and from Monterey Bay.

In its hinge structure and outline this species resembles a form collected by Arthur Earland from shore sands at Swanage, south England and identified by Dr. H. V. Howe of Louisiana State University as *Loxoconcha impressa* (Baird). Another similar form occurs in the late Tertiary beds of the Sangkoelirang Bay Area, East Borneo.

Genus PARACYTHERIDEA Müller
PARACYTHERIDEA GRANTI Le Roy, n. sp.
Plate 61, figures 11–14; plate 62, figures 3, 4; text-figure 2d′

Carapace elongate in side view, thickest near middle, highest anteriorly, triangular from interior side view; valves deep, irregular; dorsal margin rather sinuous; ventral outline straight to faintly convex, largely obscured by large, well-developed pointed ala; anterior end obliquely rounded; posterior end sharply pointed; surface of valves ornamented by irregular network of ridges; each valve bears well-developed ala at posterior ventrolateral edge; large swelling present in front of and just below posterior cardinal angle; right valve with faintly developed posterior tooth and crenulated edge; multiple notching in anterior dental area present on both valves; anterior marginal area moderately wide; pore canals very inconspicuous in specimens studied probably because of weathering.

Types.—Cotype (left valve) no. 6778; length, 1.00 mm.; height, 0.57 mm.; cotype (right valve) no. 6792; length, 0.94 mm.; height, 0.47 mm.; locality L-1, San Diego formation ("middle Pliocene").

Remarks.—This species appears to be closely related to *Paracytheridea toleri* Howe and Law (1936, p. 35, pl. II, figs. 23, 24) described from the Vicksburg Oligocene of Louisiana and to *Paracytheridea clara* Coryell and Fields (1937, p. 6, figs. 6a–c) from the Gatun formation (Miocene) of the Panama region.

The distribution of this species in southern California is rather restricted. Associated with it at the type locality are: *Brachycythere driveri, B. lincolnensis, Cythereis glauca, Cythereis diegoensis, Cythereis kewi, Hemicythere jollaensis,* and *Leguminocythereis corrugata.*

This species is named in honor of Dr. U. S. Grant of the University of California at Los Angeles.

Genus CYTHEROPTERON Sars
CYTHEROPTERON MINUTUM
Le Roy, n. sp.
Plate 60, figures 28–30

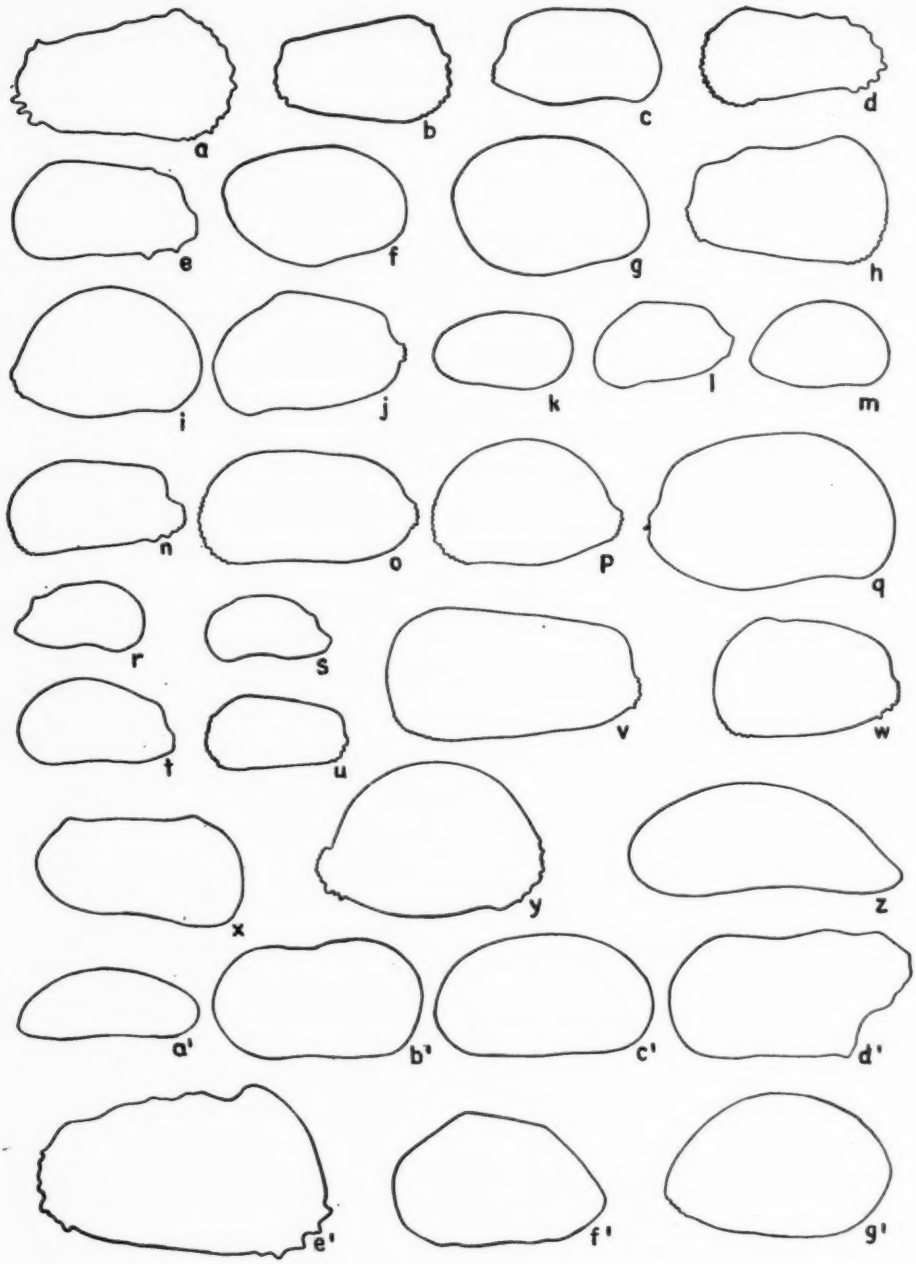
Carapace minute, thin-walled, highest anteriorly, ala very strongly developed; dorsal margin sharp, broadly and highly arched; ventral margin somewhat convexly arched, obscured posterior to middle by overhang of ala; anterior end truncate; posterior end extended, very sharply pointed; surface smooth; valves are quite deep when viewed from interior; hinge structure and marginal areas incompletely preserved.

Type.—Holotype no. 6780; length, 0.75 mm.; height, 0.57 mm.; locality L-15, Pliocene.

Remarks.—This species is known only from its type locality. It may be easily recognized by its strongly projecting ala, and truncate anterior extremity.

Genus BRACHYCYTHERE Alexander
BRACHYCYTHERE DRIVERI Le Roy, n. sp.
Plate 61, figures 6–10; plate 62, figures 17, 18; text-figure 2y

Carapace heavy, thick-walled, thickest near middle just below median line, parabolic in side view, triangular in end view with flat base and moderately convexed sides; dorsal margin strongly arched, left valve conspicuously overlapping; ventral



Magnification ±25×

FIGS. *a*—***Archicythereis holmani*** Le Roy. Paratype, no. 6811; left valve from inside. Note well-developed denticulations and divergence of straight margins. (p. 371)
b—***Archicythereis newportensis*** Le Roy. Cotype, no. 6814; left valve from inside. In general outline this species is closely similar to ***Archicythereis holmani*** (see fig. *a*). (p. 372)

surface broad, ventrolateral ridges well developed; anterior end obliquely rounded, denticulate; posterior end, slightly projecting, somewhat angulate, denticulate; surface ornamented by deep, pseudohexagonal pits of various size, those immediately above downwardly arched ventrolateral wing tend to be more elongate, somewhat deeper than those in median area; low cardinal tubercle present below dorsal edge immediately in front of large, deep, elongate subtriangular depression; hinge structure of right valve a strong, rounded, knoblike anterior tooth and deep postjacent socket merging into

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FIGS. *c*—*Hemicythereis palosensis* Le Roy. Holotype, no. 6786; right valve from exterior. Outline is remarkably constant for the species. (p. 365)

d—*Cythereis kewi* Le Roy. Paratype, no. 6799; left valve from exterior. This species exhibits strong denticulations on both extremities. (p. 369)

e—*Cythereis diegoensis* Le Roy. Paratype, no. 6806; left valve from exterior. Note strong, short spines along posteriorventral margin, and blunt posterior projection which is characteristic feature of the species. (p. 369)

f, *g*—*Loxoconcha lenticulata* Le Roy. Paratypes, two left valves from inside. *f*, form A (male?), no. 6837. *g*, form B (female?), no. 6838. Form A is more elongate and usually exhibits straighter dorsal margin than form B. This species is one of the few which shows considerable variation of outline. (p. 360)

h—*Cythereis pennata* Le Roy. Paratype, no. 6818; right valve from exterior. Note strong denticulations and straight ventral outline. (p. 370)

i, *j*—*Brachycythere lincolnensis schumannensis* Le Roy. Paratypes, i, no. 6821, *j*, no. 6822; left and right valves from interior. Note variation of dorsal outline of two valves. (p. 364)

k—*Basslerites delreyensis* Le Roy. Paratype, no. 6777; right valve from interior. Note gently arched dorsal margin and broadly rounded extremities. (p. 368)

l, *m*—*Brachycythere lincolnensis* Le Roy. Paratypes. Left and right valves from interior. Note variance of dorsal outline of two valves. (p. 364)

n—*Cythereis microreticulata* Le Roy. Paratype, no. 6825; left valve from exterior. Note strongly developed posterior projection and conspicuous denticulations. The outline of this species is remarkably constant. (p. 370)

o, *p*—*Hemicythere? californiensis* Le Roy. Paratypes, exterior of left valves of two variants of species. *o*, form A (male?), characterizes specimens with nearly parallel margins; no. 6842. *p*, form B (female?) shows distinctly arched dorsal margin more typical of genus *Brachycythere;* no. 6841. (p. 366)

q—*Hemicythere jollaensis* Le Roy. Paratype, no. 6803; left valve from inside. Note flattened S outline of ventral margin and gently arched dorsal margin. (p. 365)

r, *s*—*Caudites fragilis* Le Roy. *r*, exterior outline of right valve of holotype; no. 6788. *s*, paratype outline of right valve viewed from interior; no. 6789. This species may be identified largely by its characteristic outline. Note sharp pointed posterior and broadly rounded anterior extremity. (p. 372)

t—*Cytheridea? pedroensis* Le Roy. Paratype, no. 6828; right valve from interior. (p. 359)

u—*Cythereis schencki* Le Roy. Paratype, no. 6834; left valve from exterior. (p. 371)

v, *w*—*Cythereis glauca* Skogsberg. Plesiotypes, left valves of two varieties from exterior. *v*, form A (male?), no. 6793, is the elongate and more compressed variety. *w*, form B (female?), no. 6794, is the shorter and thicker variety. (p. 368)

x—*Leguminocythereis corrugata* Le Roy. Paratype, no. 6809; left valve from inside. Note straight dorsal margin with two minor prominence at cardinal angles. (p. 372)

y—*Brachycythere driveri* Le Roy. Paratype, no. 6782; left valve from interior. This species is conspicuous for its highly arched dorsal margin of left valve and its rather strongly developed denticulations. (p. 361)

z—*Paracypris pacificus* Le Roy. Holotype, no. 6769; exterior outline of left valve. (p. 358)

a'—*Bythocypris elongata* Le Roy. Paratype, no. 6829; exterior outline of right valve. (p. 358)

b'—*Cytherelloidea californica* Le Roy. Paratype, exterior outline of left valve. Note broadly rounded extremities and faint concavity of dorsal and ventral margins. (p. 357)

c'—*Cytheridea beaconensis* Le Roy. Paratype, no. 6831; right valve from inside. Note gently and broadly arched dorsal margin, straight ventral margin and broad, uniform rounding of extremities. (p. 359)

d'—*Paracytheridea granti* Le Roy. Cotype, no. 6778; left valve from exterior. Note apparent parallel attitude of dorsal and ventral margins. The straightness of latter is due to well developed ala. (p. 361)

e'—*Pyricythereis simiensis* Le Roy. Paratype, no. 6796; left valve from interior. Note sinuous outline of dorsal margin and strongly developed denticulations. (p. 368)

f', *g'*—*Bairdia verdesensis* Le Roy. Paratypes, no. 6773; left and right valves from interior. Note variation of dorsal marginal outline between left valve, *f'*, and right valve, *g'*. (p. 359)

moderately deep furrow that connects with elongate, slightly cusped posterior tooth; hinge of left valve with deep, anterior socket and high, elongate to knoblike postjacent tooth separated from cusped posterior socket by heavy, smooth, elevated bar; slightly concave area between bar and dorsal margin contains three to four short, rounded, parallel ridges oriented normal to hinge line; inner margin moderately wide, transversed by numerous straight pore canals; muscle pattern of several closely grouped, elliptically shaped scars (see pl. 60, fig. 36).

Types.—Holotype no. 6781 (figs. 6–8); length, 0.87 mm.; height, 0.58 mm.; thickness, 0.47 mm.; paratype no. 6775 (figs. 9, 10); length, 0.88 mm.; height, 0.60 mm.; locality L-4, Santa Barbara formation ("upper Pliocene").

Remarks.—This species is widely distributed and is common at its type locality where it is associated with *Hemicythere? californiensis*, *Cythereis glauca*, *Cythereis kewi* and *Hemicythere jollaensis*. Some Foraminifera associated with it at the type locality are: *Uvigerina tenuistriata* d'Orbigny, *Cassidulina californica* Cushman and Hughes, *Dyocibicides biserialis* Cushman and Valentine, *Elphidium crispum* (Linné), *Gaudryina grammostomata* Galloway and Wissler, *Polymorphina biserialis* Galloway and Wissler, *P. doanei* Galloway and Wissler, *Quinqueloculina* spp., *Pyrgo* sp. and *Globigerina* spp.

Brachycythere driveri is easily distinguished by its highly arched dorsal outline, conspicuous ventrolateral wings, and strongly developed hinge structure.

This species is named in honor of Mr. H. L. Driver of the Standard Oil Company of California.

Brachycythere lincolnensis Le Roy, n. sp.

Plate 61, figures 1–5; plate 62, figures 1, 2; text-figures 2l, m

Carapace medium, moderately compressed, lenticular in dorsal view, oblong ovate in side view, highest near middle, thickest along median line; left valve conspicuously larger, overlaps most prominently along posterior half of dorsal margin; dorsal margin highly arched; ventral margin gently curved upward toward posterior, distinctly curved downward at ventral anterior; posterior end broadly pointed to sharply rounded; anterior end obliquely rounded; surface smooth except for small circular to elliptically shaped pits generally aligned parallel to longitudinal axis; small cardinal tubercle present just below dorsal margin just anterior to middle; some specimens with several low ridges along ventrolateral edge; hinge structure of right valve a strongly developed, elongate to knoblike, smooth to slightly notched, anterior tooth and deep postjacent socket connected with moderately developed elongate cusped posterior tooth by narrow, shallow groove; left valve with deep anterior socket and rounded knoblike postjacent tooth connected with elongate notched posterior socket by elevated bar corresponding to groove of right valve; bar distinct from dorsal outline; inner margin at anterior end extends slightly beyond line of concrescence; radial pore canals straight, numerous, distinct; muscle area of several closely spaced ovate scars (see pl. 60, fig. 33).

Types.—Holotype no. 6783 (figs. 1–3); length, 0.60 mm.; height, 0.38 mm.; thickness, 0.28 mm.; paratype no. 6784 (figs. 4, 5); length, 0.56 mm.; height, 0.34 mm.; locality L-5, Terrace deposits (Pleistocene).

Remarks.—This species is moderately well distributed and several specimens were found in recent sediments off Santa Catalina Island. Some Foraminifera associated at the type locality include: *Elphidium spinatum* Cushman and Valentine, *Elphidiella hannai* (Cushman and Grant), *Elphidium translucens* Natland, and *Orbulina universa* d'Orbigny.

Brachycythere lincolnensis schumannensis Le Roy

Plate 59, figures 1–6; text-figures 2i, j

This variety differs from the typical form of the species by the better development of its ventrolateral ridge. It is generally larger and more robust. Four or five small vertical ridges are present in the area between the hinge bar and dorsal margin of the left valve as in the typical form.

Types.—Holotype no. 6819 (figs. 1–4);

length, 0.80 mm.; height, 0.55 mm.; thickness, 0.43 mm.; paratype no. 6820 (figs. 5, 6); length, 0.78 mm.; height, 0.50 mm.; locality L-12, Foxen formation ("Pliocene").

Remarks.—This species has been collected from the Imperial formation of the Coyote Mountain Area, Imperial County, California, and from the Miocene (*Bolivina hughesi* zone) at a locality scaled 7.15 inches north and 4.05 inches west from southeast corner of the Covina Quadrangle, Los Angeles County, California.

Genus HEMICYTHERE Sars

HEMICYTHERE PALOSENSIS Le Roy, n. sp.
Plate 60, figures 14–18; text-figure 2c

Carapace subquadrate in side view, highest anteriorly, anterior cardinal tubercle distinct; dorsal margin gently arched; posterior dorsal angle sharp; anterior dorsal angle broad; ventral margin with distinct lip indentation just anterior to middle; anterior end broadly, obliquely rounded; posterior end with prominent, blunt projection below; surface strongly reticulate, distinct curved ridge extends along ventrolateral edge, two rather prominent slightly diverging ridges extend forward from slightly raised median node area to connect with anterior marginal ridge; moderately developed projection just below posterior dorsal angle; hinge structure strong, well developed; hinge margin of left valve bears deep, anterior socket, well developed, rounded postjacent tooth, high bar separated from dorsal margin by moderately wide area, and elongate, curved, deep posterior socket; hinge of right valve a strong, notched, rounded anterior tooth, postjacent socket, narrow groove and low, curved, elongate cusped posterior tooth; marginal areas wide around anterior, ventral, posterior, with numerous, closely spaced, straight pore canals; muscle scar pattern five to seven small, grouped, ovate spots (see pl. 60, fig. 34).

Types.—Holotype no. 6786 (figs. 14–16); length, 0.69 mm.; height, 0.40 mm.; thickness, 0.33 mm.; paratype no. 6787 (figs. 17, 18); length, 0.70 mm.; height, 0.43 mm.; locality L-10, Lomita marl ("Pleistocene").

Remarks.—This species is rare. In Avalon Bay, Santa Catalina Island, it occurs at depth of 8.5 m. with bottom temperature 17.17°C. A few specimens were also collected in Monterey Bay and several have been obtained from the Imperial formation of Coyote Mountain, Imperial Valley, California.

HEMICYTHERE JOLLAENSIS Le Roy, n. sp.
Plate 59, figures 28–33; plate 62, figures 15, 16; text-figure 2q

Carapace medium, heavy, thickest along median portion and near middle, highest near middle, triangular in end view, with faint anterior dorsal cardinal tubercle in front of large elongate depression; left valve larger, overlap most conspicuous along dorsal margin; dorsal outline broadly arched; ventral margin faintly concave just anterior to middle; ventral surface broad; anterior end obliquely rounded, denticulate; posterior end bluntly pointed, short denticulations on lower part; posterior dorsal angle strongly developed; surface of valves strongly reticulate; strong ventrolateral ridge reaches greatest height posteriorly; second medium sized ridge extends along part of dorsal margin giving dorsal surface grooved cross section; characteristic median ridge, beginning just posterior to middle extends to anterior rim; most specimens have slight ridge projection just below posterior dorsal angle; hinge of left valve a deep, circular anterior socket with high, rounded, postjacent knoblike tooth connected to low curved, elongate posterior socket by elevated, moderately rounded, smooth bar paralleling dorsal margin but separated from it by narrow area; hinge structure of right valve a high, rounded, smooth, anterior tooth and deep, rounded postjacent socket merging into broad groove that terminates in elongate, smooth, curved, cusped, posterior tooth; marginal area wide, contains numerous, straight pore canals; for details of muscle scar pattern see pl. 4, fig. 39.

Types.—Holotype no. 6801 (figs. 28–31); length, 0.95 mm.; height, 0.65 mm.; thickness, 0.57 mm.; paratype no. 6802 (figs. 32, 33); length, 0.93 mm.; height, 0.60 mm.; locality L-1, San Diego formation ("middle Pliocene").

Remarks.—This species is widely dis-

tributed. Its surface pattern is remarkably constant.

HEMICYTHERE? CALIFORNIENSIS
Le Roy, n. sp.
Plate 61, figures 29–33; plate 62, figures 5, 6; text-figures 2o, p

Carapace rather large, heavy, thick-walled, thickest posterior to middle, height and maximum thickness about equal, subquadrate in side view, thickly lenticular in dorsal view; ventral surface slightly convex in end view, dorsal surface more sharply rounded; dorsal margin straight to faintly curved; margins diverge only slightly toward anterior; posterior end somewhat truncate to slightly angled; anterior end obliquely rounded; denticulate posteriorly and anteriorly; surface ornamented with numerous pits of nearly equal size separated by rounded ridges of uniform height; low, rounded cardinal tubercle present on each valve at anterodorsal angle; deep, elongate pit just behind tubercle; hinge of right valve with medium sized, somewhat elongate to moderately pointed, smooth, anterior tooth and elongate postjacent socket merging into narrow, very finely crenulated to smooth groove connected to elongate, moderately compressed, smooth or cusped posterior tooth; hinge of left valve with deep, round to elongate socket and small, rounded postjacent tooth connected to elongate posterior socket by well-developed, minutely crenulated to smooth elevated bar distinctly separated from dorsal margin; line of concrescence on anterior end lies close and coincides approximately with inner margin except for slight divergence below; numerous, closely spaced, straight radial pore canals in marginal area; muscle area depression anterior, slightly below median line, surrounded by six to eight small ovate scar spots (see pl. 60, fig. 32).

Types.—Holotype no. 6839 (figs. 29–31, form A); length, 0.77 mm.; height, 0.48 mm.; thickness, 0.45 mm.; paratype no. 6840 (figs. 32, 33, form A); length, 0.85 mm.; height, 0.50 mm.; locality L-1, San Diego formation ("middle Pliocene").

Remarks.—Two forms of the typical variety of this species are recognized. The commoner, form A, is distinguished by its almost flat dorsal outline.

Some specimens of this species seem to have a finely crenulated hinge groove and bar but most do not.

This species is widely distributed and it is generally abundant particularly at the type locality and in the Santa Barbara beds at Bath House Beach. It occurs in considerable

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EXPLANATION OF PLATE 61

FIGS. *1–5—Brachycythere lincolnensis* Le Roy, n. sp. ×48. Holotype, figs. 1–3, no. 6783. Paratype, figs. 4, 5, no. 6784. *1*, right valve; *2*, dorsal view; *3*, ventral view; *4*, *5*, inside view of right and left valves showing hinge structure and marginal areas. (p. 364)

6–10—Brachycytheri driveri Le Roy, n. sp. ×32. Holotype, figs. 6–8, no. 6781. Paratype, figs. 9, 10, no. 6775. *6*, right valve; *7*, dorsal view; *8*, ventral view; *9*, *10*, inside view of right and left valves showing hinge development and marginal areas. (p. 361)

11–14—Paracytheridea granti Le Roy, n. sp. ×30. Cotype, figs. 11, 12, 14, left valve, no. 6778. Cotype, fig. 13, right valve, no. 6792. *11*, left valve; *12*, dorsal view of left valve; *13*, *14*, inside view of right and left valves showing hinge structure. (p. 361)

15–18—Paracypris pacificus Le Roy, n. sp. ×29. Holotype, figs. 15–17, no. 6769. Paratype, fig. 18, left valve, no. 6770. *15*, right valve; *16*, dorsal view; *17*, ventral view; *18*, inside view of left valve. (p. 358)

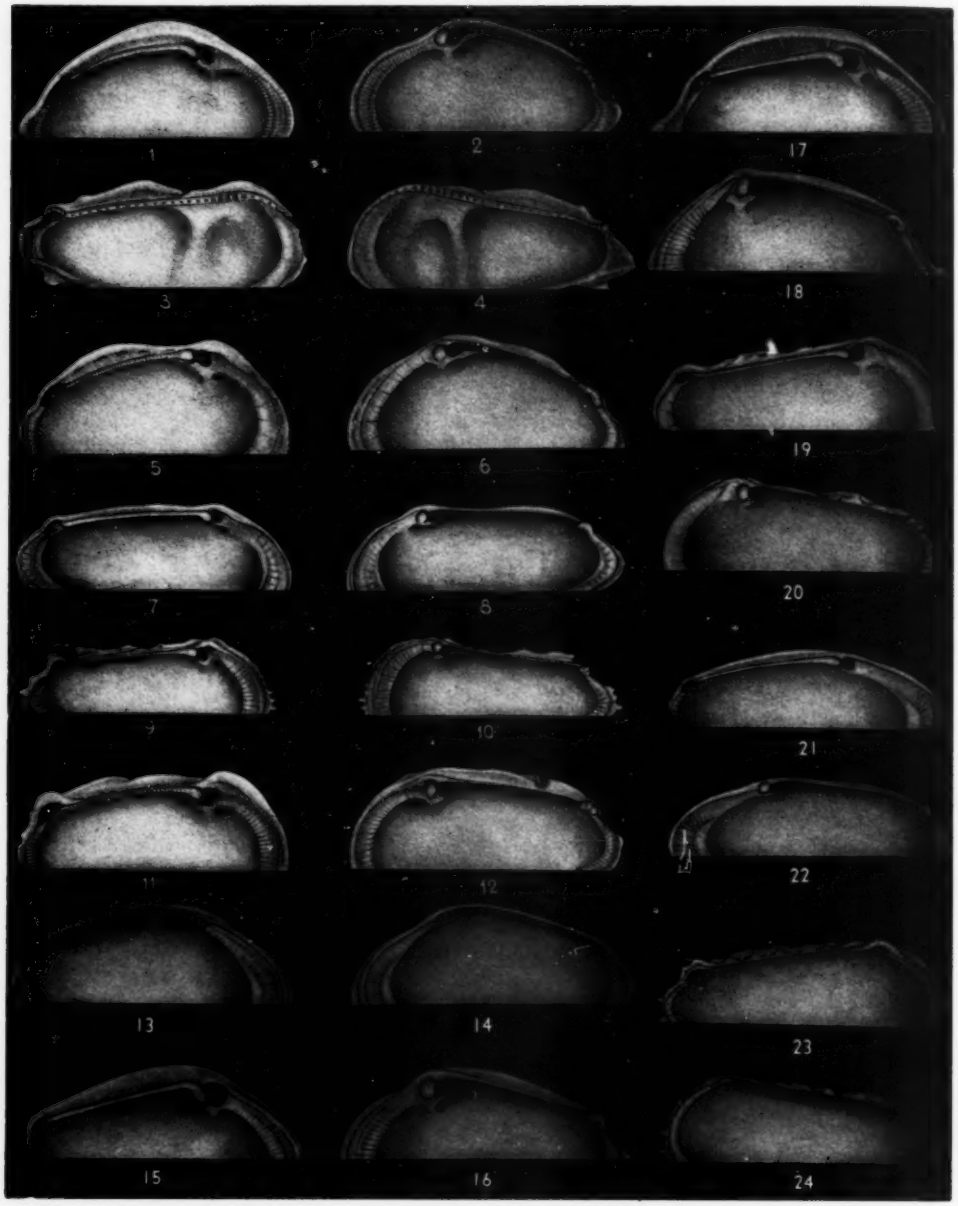
19–23—Cythereis glauca Skogsberg, ×35. Plesiotypes, figs. 19–21, no. 6790; figs. 22, 23, no. 6791. *19*, right valve; *20*, dorsal view; *21*, ventral view; *22*, *23*, inside view of right and left valves showing hinge development. (p. 368)

24–28—Pyricythereis simiensis Le Roy, n. sp. ×24. Holotype, figs. 24–26, no. 6795. Paratype, figs. 27, 28, no. 6796. *24*, right valve; *25*, dorsal view; *26*, ventral view; *27*, *28*, inside view of right and left valves showing hinge structure and marginal area. (p. 368)

29–33—Hemicythere? californiensis Le Roy, n. sp. ×36. Holotype, figs. 29–31, form A, no. 6839. Paratype, figs. 32, 33, form A, no. 6840. *29*, right valve; *30*, dorsal view; *31*, ventral view; *32*, *33*, inside view of right and left valves showing hinge structure and marginal area. (p. 366)

34–36—Loxoconcha lenticulata Le Roy, n. sp. ×40. Paratype, form A, female?, no. 6774. *34*, right valve; *35*, dorsal view; *36*, ventral view. (p. 360)

LeRoy, Pleistocene and Pliocene Ostracoda



LeRoy, Pleistocene and Pliocene Ostracoda

numbers in Avalon Bay, Santa Catalina Island.

Associated with this species at the type locality are: *Brachycythere driveri, B. lincolnensis, Hemicythere jollaensis, Cythereis glauca, C. diegoensis, C. kewi* and several other forms. Some associated Foraminifera include: *Elphidium crispum* (Linné), *Cibicides* aff. *concentrica* Cushman, *Cassidulina californica* Cushman and Hughes, *Cibicides lobatulus* (Fichtel and Moll), *Gaudryina grammostomata* Galloway and Wissler, *G. arenaria* Galloway and Wissler, and *Globigerina* sp.

HEMICYTHERE? CALIFORNIENSIS HISPIDA Le Roy

Plate 60, figures 1–4

This variety differs from the typical form of the species by the distinct spinose character of the reticulated surface, the development of a rather prominent ridge along the ventrolateral edge and the more prominently truncated posterior extremity. See pl. 60, fig. 31, for details of muscle scar pattern.

Types.—Holotype no. 6815 (figs. 1–3); length, 0.96 mm.; height, 0.57 mm.; thickness, 0.51 mm.; paratype no. 6816 (right valve, fig. 4); length, 0.94 mm.; height, 0.53 mm.; locality L-4, Santa Barbara formation ("upper Pliocene").

Remarks.—This species is rare. It occurs in Avalon Bay (Clark and Natland Station 66), Santa Catalina Island at a depth of 8.5 m.

EXPLANATION OF PLATE 62

Details of hinge structure drawn by Damin.

FIGS. *1, 2—Brachycythere lincolnensis* Le Roy ×100. *1*, paratype, no. 6785, left valve; *2*, right valve. Note that smooth, faintly curved bar of left valve is distinctly separated from dorsal margin by narrow slightly depressed area. The elongate, somewhat compressed, cusped posterior tooth shown on right valve of figured specimen is frequently found to be quite smooth. (p.364)

3, 4—Paracytheridea granti Le Roy ×59. *3*, cotype, no. 6845, left valve; *4*, right valve. This species is typified by its small, somewhat cusped posterior tooth, its narrow, distinctly crenulated edge and its notched anterior dental area. (p. 361)

5, 6—Hemicythere? californiensis Le Roy ×78. *5*, paratype, no. 6846, left valve; *6*, right valve. This species shows a minutely crenulated bar and corresponding groove on the left and right valves respectively. The anterior dental elements of both valves are rather well developed. The posterior tooth is typically cusped, low and elongate. (p. 366)

7, 8—Leguminocythereis corrugata Le Roy ×68. *7*, paratype, no. 6800, left valve; *8*, right valve. (p. 372)

9, 10—Cythereis kewi Le Roy ×61. *9*, paratype, no. 6843, left valve; *10*, right valve. The groove and bar of this species is minutely crenulate. On many specimens crenulations are difficult to observe. As general rule posterior tooth is only moderate in size, whereas anterior dental elements are quite strongly developed. (p. 369)

11, 12—Cythereis glauca Skogsberg ×63. *11*, paratype, no. 6844, left valve; *12*, right valve. Dental elements of this species are strongly developed. The bar and groove are minutely crenulate. Posterior tooth of right valve tends to be somewhat cusped. (p. 368)

13, 14—Loxoconcha lenticulata Le Roy ×81. *13*, paratype, no. 6847, left valve; *14*, right valve. This species possesses distinct crenulated hinge margin. Anterior dental area consists of series of nodes and notches, whereas posterior element of left valve consists of notched socket corresponding to indented posterior tooth of right valve. (p. 360)

15, 16—Hemicythere jollaensis Le Roy ×75. *15*, paratype, no. 6848, left valve; *16*, right valve. Hinge elements of this species are strongly developed. The bar of left valve is distinctly separated from dorsal margin. (p. 365)

17–18—Brachycythere driveri Le Roy ×60. *17*, paratype, no. 6849, left valve; *18*, right valve. Note strongly developed hinge elements and low vertical ridges in area just above bar of left valve, typical of this species. (p. 361)

19–20—Cythereis pennata Le Roy ×73. *19*, paratype, no. 6850, left valve; *20*, right valve. Hinge elements of this species are strongly developed and quite typical of the genus. (p. 370)

21–22—Basslerites delreyensis Le Roy ×100. *21*, paratype, no. 6851, left valve; *22*, right valve. Hinge elements of this species are quite characteristic of genus. Left valve has deep, rounded to somewhat elongate anterior socket and rather high postjacent tooth sloping backward to merge with elevated, smooth bar that is separate by incised line from dorsal margin and which finally terminates abruptly at elongate posterior socket. (p. 368)

23, 24—Archicythereis holmani Le Roy ×66. *23*, left valve; *24*, right valve, no. 6852. This species clearly shows the two, low elongate, faintly cusped teeth on right valve and connecting finely crenulated groove. Left valve has no teeth, only two elongate sockets separated by narrow, finely crenulated edge. (p. 371)

Genus BASSLERITES Coryell and Field
BASSLERITES DELREYENSIS Le Roy, n. sp.
Plate 59, figures 23–27; plate 62, figures 21, 22; text-figure 2k

Carapace elongate in side view, about twice as long as high, thickest and highest near middle; dorsal margin slightly arched; ventral outline nearly straight; anterior end evenly rounded; posterior end more broadly rounded; valves subequal, left overlapping right around almost entire periphery; surface smooth, finely perforate; calcified portion of inner lamella slightly developed in middle anterior; radial pore canals moderate in number, spacing somewhat irregular; hinge of left valve a deep rounded to somewhat elongate anterior socket and rather high, pointed postjacent tooth sloping backward to merge with elevated, smooth bar separated by incised line from dorsal margin terminating abruptly at elongate posterior socket; elements of hinge of right valve coincide with those of left; for muscle pattern see plate 60, figure 35.

Types.—Holotype no. 6776 (figs. 23–26); length, 0.57 mm.; height, 0.30 mm.; thickness, 0.28 mm.; paratype no. 6777 (fig. 27); length, 0.57 mm.; height, 0.32 mm.; locality L-5, Terrace deposits (Pleistocene).

Remarks.—This species is rare at the type locality and seems to have a restricted areal distribution. It appears to be closely related to *Basslerites miocenica* (Howe) (1935, p. 31, pl. I, figs. 19, 24–26) from the Choctawkatchee Miocene of Florida, but differs by being somewhat larger, generally more elongate and less angular posterior dorsally.

Genus PARICYTHERESIS Howe
PYRICYTHEREIS SIMIENSIS Le Roy, n. sp.
Plate 61, figures 24–28; text-figure 2é

Carapace elongate, subquadrate in side view, heavy, highest anteriorly, thickest near middle; dorsal and ventral margins nearly straight, diverging slightly toward anterior; anterior end broadly, obliquely rounded, strongly denticulate, rimmed; posterior end flatly rounded, strongly denticulate; posterior and anterior dorsal angles rather well developed; surface ornamented with numerous, high, sharp, irregular ridges; three ridges conspicuously developed, at dorso- and ventrolateral edges and along median portion; last ridge commonly highest; hinge structure very strongly developed; finely crenulated hinge margin inconspicuous on most specimens; marginal areas wide, with numerous straight, occasionally intersecting pore canals; muscle scar area depressed, circular.

Types.—Holotype no. 6795 (figs. 24–26); length, 1.20 mm.; height, 0.64 mm.; paratype no. 6796 (figs. 27, 28); length, 1.16 mm.; height, 0.63 mm.; locality L-7, San Diego formation ("middle Pliocene").

Remarks.—This species is rare in the San Diego beds of the Simi Valley, but it abounds and is typically developed at locality L-9. Its vertical distribution appears to be rather restricted to the Pliocene. This species may be a matured form of *Archicythereis newportensis* or *A. holmani.*

This species is readily recognized by its heavy, thick-walled valves and surface network of high sharp, irregular ridges. Foraminifera associated with the holotype include: *Globorotalia grandis* Galloway and Wissler, *Polymorphina frondicula riformis* Galloway and Wissler, *Polymorphina doanei* Galloway and Wissler, *P. biserialis* Galloway and Wissler, *P. austriaca* d'Orbigny, *Gaudryina grammostomata* Galloway and Wissler, *G. arenaria* Galloway and Wissler, *Cassidulina californica* Cushman and Hughes, *C. spiralis* Natland, *Elphidium crispum* (Linné) and *Globigerina* spp.

Genus CYTHEREIS Jones
CYTHEREIS GLAUCA Skogsberg
Plate 61, figures 19–23; plate 62, figures 11, 12; text-figures 2v, w

Cythereis glauca Skogsberg, 1928, California Acad. Sci., p. 110, pl. 3, figs. 2, 6, 7; pl. 4, fig. 4.

Carapace medium, thick-shelled, robust, elongate, subquadrangular in side view, thickest posterior to middle, highest anteriorly; anterior view roundly quadrate, dorsal and ventral surfaces nearly parallel, sides moderately convex; anterior end obliquely rounded, faintly denticulate; posterior end truncate, blunt projection on lower part, denticulate; surface strongly reticulate; moderately high ridge near ventrolateral edge extending entire length

of ventral side, turning upward at ventral anterior angle, continuing as rim around anterior margin; on specimens diagonal ridge extends roughly from posterior dorsal angle to anterior ventral angle, passing through faint muscle scar node; slight ridge projection may occur at or just below posterior dorsal angle; hinge structure strongly developed; right valve with rounded, knoblike anterior tooth and deep postjacent socket connected to moderately developed posterior tooth by narrow, shallow, very faintly crenulated furrow; hinge of left valve with deep anterior socket and knoblike postjacent tooth separated from slightly elongate posterior socket by narrow, straight, minutely crenulated margin; marginal area with numerous, closely spaced, straight radial pore canals; line of concrescence coincides approximately with inner margin; muscle scar represented by depression located slightly anterior along the median line.

Types.—Plesiotypes no. 6790 (figs. 19–21); length, 0.80 mm.; height, 0.46 mm.; thickness, 0.33 mm.; no. 6791, figs. 22, 23; length, 0.75 mm.; height, 0.43 mm.; locality L-4, Santa Barbara formation ("upper Pliocene").

Remarks.—The surface sculpture of this species is rather constant but the height-length ratio varies somewhat (compare forms A and B, text-fig. 3v, w). Because of the minutely crenulated hinge margin, this species may possibly be referred to the genus *Pyricythereis* Howe whose hinge structure was described as "similar to *Cythereis* but the groove which parallels the dorsal margin of the right valve is distinctly crenulate as is the bar of the left valve."

This species was originally described from a tidal pool in Carmel Bay, California. It is common in recent sediments of Avalon Bay, Santa Catalina Island, and has been observed in the Imperial formation of Painted Hills area, San Jacinto Quadrangle, Riverside County, California. It is one of the most common fossil forms.

CYTHEREIS DIEGOENSIS Le Roy, n. sp.
Plate 58, figures. 26–31; text-figure 2e

Carapace elongate in side view, compressed; dorsal and ventral margins nearly parallel; anterior end broadly, obliquely rounded; posterior end truncate; several blunt spines on lower ventroposterior margin; dorsal cardinal angles rather well developed; small, low anterior cardinal tubercle present; surface ornamented by distinct network of sharp ridges of remarkable constancy; muscle scar node very slightly developed; hinge structure typical; marginal areas wide, with many straight, closely spaced pore canals; muscle depression just anterior to middle, near the median line.

Types.—Holotype no. 6804 (figs. 26–29); length, 0.75 mm.; height, 0.40 mm.; thickness, 0.28 mm.; paratype no. 6805 (figs. 30, 31); length, 0.72 mm.; height, 0.40 mm.; locality L-1, San Diego formation ("middle Pliocene").

Remarks.—This species rather abundant at the type locality where it is associated with *Hemicythere? californiensis*, *Cythereis kewi*, *Hemicythere jollaensis*, and *Cythereis glauca*. It differs from *Cythereis glauca* Skogsberg by being more compressed and by having higher and more distinct surface ridges.

CYTHEREIS KEWI Le Roy, n. sp.
Plate 60, figures 24–27;
plate 62, figures 9, 10;
text-figure 2d

Carapace elongate, rectangular in side view; dorsal and ventral margins straight, diverging very slightly from posterior end; anterior end broadly rounded, rim heavy, strongly denticulate; posterior end subangular, bearing several well-developed spines on lower part; surface smooth to minutely reticulate; prominent median muscle scar node just anterior to middle; small but prominent cardinal tubercle near dorsal anterior angle; beginning at ventroanterior angle an outward-flaring ventrolateral extends backward to a point just posterior to middle, thence angles upward to intersect another short outward-flaring ridge extending backward along posterior half of dorsal margin; several minor ridges extend upward from ventrolateral ridge for short distance; valves moderately deep as viewed from inside; hinge of left valve with deep, circular anterior socket and high, knoblike postjacent tooth sharply merging with smooth to

minutely crenulated, straight dorsal edge that terminates at deep, slightly elongate posterior socket; hinge of right valve with high rounded, smooth anterior tooth deep postjacent socket, narrow, smooth to minutely crenulated marginal furrow and smooth, somewhat elongate posterior tooth; marginal areas broad, with numerous, closely spaced, straight pore canals; muscle scar circular, depressed.

Types.—Holotype no. 6797 (figs. 24–26); length, 0.88 mm.; height, 0.45 mm.; paratype no. 6798 (fig. 27); length, 0.86 mm.; height 0.45 mm.; locality L-4; Santa Barbara formation ("upper Pliocene").

Remarks.—This species is easily identified by its ornamentation. It is rarely found in large numbers but its distribution appears to be rather widespread. Several specimens were found in the Imperial formation of the Coyote Mountain area, Imperial County, California. *Brachycythere driveri*, *B. lincolnensis*, *Loxoconcha lenticulata*, *Cythereis glauca*, *Hemicythere jollaensis*, and *Hemicythere? californiensis* are found associated with it at the type locality.

This species appears to be related to *Cythereis hysonensis* var. *dohmi* Howe and Chambers (1935, p. 32, pl. 1, fig. 9) described from the Jackson Eocene of Louisiana.

This species is named in honor of Dr. W. S. W. Kew of the Standard Oil Company of California.

CYTHEREIS MICRORETICULATA Le Roy, n. sp.
Plate 59, figures 17–22;
text-figure 2n

Carapace medium, elongate, somewhat compressed, highest anteriorly; dorsal and ventral margins straight, subparallel; anterior dorsal cardinal angle broad, posterior dorsal angle very sharp; anterior extremity obliquely rounded, compressed, with low, narrow rim, denticulate; posterior extremity angulate, conspicuously projecting in lower half, denticulate; surface minutely reticulate, ridges very low, narrow, intersecting to form pseudopentagonal and quadrangular units, each containing small dot or short ridge of limbate shell material in middle; low ridge extending part way along ventrolateral edge terminates in rather sharp, backward pointing ala; faint muscle scar swelling occurs medianly just anterior to middle; slight projection just below dorsal posterior angle; hinge structure typical; anterior marginal area moderately wide, with many straight, closely spaced radial pore canals; muscle scar depressed, circular.

Types.—Holotype no. 6823 (figs. 17–20); length, 0.75 mm.; height, 0.38 mm.; thickness, 0,30 mm.; paratype no. 6824 (figs. 21, 22); length, 0.75 mm.; height, 0.35 mm.; locality L-4, Santa Barbara formation ("upper Pliocene").

Remarks.—The general outline, compressed character, and finely reticulate surface pattern, which is quite uniform, distinguish this species. It is quite rare at the type locality and elsewhere.

CYTHEREIS PENNATA Le Roy, n. sp.
Plate 59, figures 34–37;
plate 62, figures 19, 20;
text-figure 2h

Carapace subrectangular, elongate in side view, valves heavy; dorsal and ventral margins straight to slightly sinuous, diverging anteriorly; anterior extremity obliquely rounded, rimmed, denticulate; posterior end truncate, with several short, blunt spines near ventral angle; surface covered with minor heavy, rounded, rather high ridges; median muscle node well-developed just in front of center; two irregular ridges extend forward from node, merge with anterior surface before reaching anterior rim; ventrolateral ridge conspicuous, winglike; another ridge, beginning just anterior to middle below dorsal margin, extends upward and along dorsolateral edge to point below posterior dorsal angle, flares outward producing blunt projection, turns inward to margin and thence extends around posterior, ventral and anterior margins; well-developed cardinal tubercle present at anterior dorsal angle; hinge of left valve with deep, rounded anterior socket and rather large, smooth, pointed postjacent tooth merging abruptly with straight, smooth dorsal edge that terminates at slightly elongate posterior socket; hinge of right valve with strongly developed, smooth anterior tooth, moderately deep postjacent socket, narrow marginal groove

and faintly cusped, slightly elongated posterior tooth; marginal areas wide, with numerous, closely spaced radial pore canals; muscle scar an irregular depression.

Type.—Holotype no. 6817; length, 0.90 mm.; height, 0.50 mm.; thickness, 0.55 mm.; locality L-1, San Diego formation ("middle Pliocene").

Remarks.—This species is of the winged type. It may be identified by its heavy valves, general outline and the characteristic surface ridge pattern.

CYTHEREIS SCHENCKI Le Roy, n. sp.
Plate 58, figures 9–14;
text-figure 2u

Carapace small, elongate, highest anteriorly, thickest posteriorly; dorsal margin straight; ventral margin slightly concave near middle; posterior dorsal cardinal angle sharp; anterior cardinal angle broad, with small tubercle; anterior end obliquely rounded, faintly rimmed, denticulate; posterior end truncate to angulate, denticulate; surface pitted, with low ridges tending to spiral around faint muscle scar swelling located medianly just anterior to middle; blunt protuberances present on posterior ventral half; hinge of right valve a small, low, rounded to elongate anterior tooth, a small postjacent socket separated from low, cusped, elongate posterior tooth by long, straight, narrow, marginal furrow; hinge of left valve an anterior socket, very minute postjacent tooth separated from elongate posterior socket by high, narrow, marginal edge; marginal areas wide, with moderate number of widely spaced straight pore canals; inner margin extends slightly beyond line of concrescence on lower part of anterior; muscle scar circular, depressed.

Types.—Holotype no. 6832 (figs. 9–12); length, 0.55 mm.; height, 0.28 mm.; thickness, 0.26 mm.; paratype no. 6833 (figs. 13, 14); length, 0.61; height 0.33 mm.; locality L-4, Santa Barbara formation ("upper Pliocene").

Remarks.—This species is common at its type locality and is moderately distributed elsewhere. It is named in honor of Dr. H. G. Schenck, Stanford University, California.

Genus PYRICYTHEREIS
Genus ARCHICYTHEREIS Howe
ARCHICYTHEREIS HOLMANI Le Roy, n. sp.
Plate 58, figures 1–4;
plate 62, figures 23, 24;
text-figure 2a

Carapace medium, elongate-quadrate in side view; dorsal and ventral margins straight, tending to converge posteriorly; anterior end broadly, obliquely rounded, strongly denticulate, with distinct, high, sharp marginal rim; posterior end compressed, somewhat angulate, strongly denticulate along lower part; dorsal angles well developed; surface strongly reticulate; very sharp ridge extends partially along ventrolateral edge; another prominent irregular ridge present along dorsolateral margin; low ridges on anterior half tend to radiate from faint median swelling just anterior to middle; marginal areas very narrow, contain moderate number of straight inconspicuously developed radial pore canals; hinge structure typical, consisting in left valve of two elongate sockets separated by finely crenulated margin, in right valve of two small, low, elongate, faintly cusped teeth separated by narrow crenulated groove corresponding to edge of left valve; muscle scar depressed, details not known.

Type.—Holotype no. 6810; length, 0.90 mm.; height, 0.52 mm.; locality L-9 "Upper Pliocene." Newport Lagoon.

Remarks.—This species occurs abundantly at its type locality but it has not been noted elsewhere. It is readily distinguished by its surface ornamentation and by its narrow marginal areas.

Associated foraminifera are similar to assemblages found in the San Diego formation ("middle Pliocene") of Pacific Beach, San Diego County, and Lomita formation ("Pleistocene") of the Palos Verdes Hills, Los Angeles County. *Pyricythereis simiensis* and *Archicythereis newportensis* are found in great numbers at the type locality of this species.

Howe (1936, pp. 57, 58), in discussing the generic characteristics of *Archicythereis* suggests that this genus may represent a "young molt" of an adult form. This observation is interesting, as at locality L-9 *Pyricythereis simiensis, Archicythereis hol-*

mani and *A. newportensis* are quite abundant and are associated with only a few other species. It is not unlikely that the latter two forms represent early molt stages of the species *Pyricythereis simiensis*. If such be the case, *Archicythereis newportensis* is indicative of the youngest stage and *A. holmani* of the intermediate stage.

ARCHICYTHEREIS NEWPORTENSIS Le Roy, n. sp. Plate 58, figures 5–8; text-figure 2b

Carapace small, thin-shelled, highest near dorsal anterior angle; dorsal and ventral margins straight, diverging posteriorly; anterior extremity broadly rounded, slightly oblique, denticulate; posterior extremity blunt, somewhat angulate, denticulate; dorsal cardinal angles well developed; surface ornamentation distinct, constant; thin transparent rim extends from anterior dorsal angle around anterior end and backward along ventral border; high, sharp ridge present just below dorsal margin, another extends along ventrolateral edge; several very low, inconspicuous, narrow ridges radiate toward anterior margin from slightly elevated, rounded muscle scar swelling; hinge typical of genus; marginal areas very narrow, contain generally inconspicuous straight radial pore canals in moderate numbers; muscle scar pattern unknown.

Types.—Cotype no. 6813 (figs. 5, 6, right valve); length, 0.75 mm.; height, 0.45 mm.; cotype no. 6812 (figs. 7, 8, left valve); length, 0.72 mm.; height, 0.45 mm.; locality L-9, "Upper Pliocene," Newport Lagoon.

Remarks.—This species is common at its type locality. It may be an early stage of *Archicythereis holmani*, but intermediate molts have not been observed The carapace as a whole and its surface ornamentation are not so strongly developed as in *A. holmani*.

Genus LEGUMINOCYTHEREIS Howe
LEGUMINOCYTHEREIS CORRUGATA Le Roy, n. sp. Plate 59, figures 7–12; plate 62, figures 7, 8; text-figure 2x

Carapace elongate in side view, about twice as long as high, left valve conspicuously larger overlaps around entire periphery; dorsal and ventral margins nearly parallel; dorsal margin straight; ventral margin slightly concave just anterior to middle; anterior end broadly, obliquely rounded; posterior end rather sharply rounded to somewhat angulate; surface ornamented by series of rounded, longitudinal ridges slightly diagonal to median axis; narrow troughs between ridges distinctly pitted; faint cardinal tubercle present; right valve with strong, sharp anterior tooth, rounded postjacent socket, narrow grooved margin merging with very high, smooth, slightly elongate posterior tooth; hinge of left valve with anterior socket, small, rounded postjacent tooth, narrow, straight, rounded, elevated margin and slightly elongate posterior socket; marginal areas moderately wide, particularly on anterior extremity where inner margin in ventral half extends slightly beyond line of concrescence; radial pore canals straight, moderately numerous, sometimes intersecting; muscle scar a depressed area.

Types.—Holotype no. 6807 (figs. 7–10); length, 1.05 mm.; height, 0.55 mm.; thickness 0.45 mm.; paratype no. 6808 (figs. 11, 12); length, 0.90 mm.; height, 0.40 mm.; locality L-1, San Diego formation ("middle Pliocene").

Remarks.—This species can be readily identified by its surface ridges and its general outline. It is rare.

Genus CAUDITES Coryell and Fields
CAUDITES FRAGILIS Le Roy, n. sp. Plate 60, figures 10–13; text-figures 2r, s

Carapace very small, elongate, compressed, thin-shelled, highest anteriorly; dorsal margin flatly arched; ventral margin sharply concave just anterior to middle; anterior extremity obliquely rounded; posterior extremity extended, bluntly pointed, faintly upturned; dorsoposterior angle quite distinct; surface smooth; very low, broad ridge extends from conspicuous projection just below dorsoposterior angle to point near middle and just back of anterior margin where it splits into two branches; one turns upward, curves backward, merges with cardinal tubercle; other arches downward toward anterior ventral angle, dies out or continues back for short distance along

ventrolateral edge; faint, narrow ridge, paralleling posterior margin, culminates in dorsoposterior projection, continues forward for short distance along dorsolateral edge; hinge of right valve a high, rounded anterior tooth, very inconspicuous postjacent elongate socket, narrow, curved marginal groove and elongate, low posterior tooth; hinge of left valve a deep anterior socket, faint postjacent tooth, narrow, elevated, slightly curved bar and elongate posterior socket; marginal areas wide; pore canals straight, simple, numerous, may be partially observed from exterior.

Types.—Holotype no. 6788 (figs. 10–12); length, 0.54 mm.; height, 0.30 mm.; thickness, 0.18 mm.; paratype no. 6789 (fig. 13); length, 0.51 mm.; height, 0.25 mm.; locality L-10, Lomita marl ("Pleistocene"), City of San Pedro.

Remarks.—This species may be recognized by its general outline, compressed character and the dorsal posterior projection. It is rare. A few specimens have been found in recent sediments of Monterey Bay.

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ORDOVICIAN CONODONT FAUNAS FROM OKLAHOMA

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ABSTRACT—Conodonts of four faunas from the Middle Ordovician of Oklahoma are described and illustrated. Specimens of *Leptochirognathus*, a new genus, are very abundant in the McLish formation and one species of the genus was found in the lower Bromide. The Bromide and Joachim conodont faunas are closely related and the Plattin and Viola have seven conodont species in common. Four species are common to the McLish and Dutchtown.

A REMARKABLE section through Ordovician sandstones, shales, and limestones is exposed in a series of road cuts along Oklahoma State Highway 48 about 14 miles south of Ada, Pontotoc County, in sec. 12, T. 1 N., R. 6 E. (exact location not confirmed). The section includes the Arbuckle group at the base, followed by the McLish, the Bromide, and the Viola. The complete section as developed in the Arbuckle Mountains includes, in ascending order above the Arbuckle; Joins, Oil Creek, McLish, Bromide, Tulip Creek, and Viola. In the section here described the Oil Creek and the Joins have been faulted out between the Arbuckle and McLish, and the Tulip Creek does not occur in this region.

The writers have studied this section together and separately several times, in most cases in company with some other geologist well acquainted with Oklahoma stratigraphy. They have noted that the exact boundaries of the exposed formations are not well agreed upon by these observers although in all cases there is general agreement concerning the gross features of the succession. The lack of agreement in the details is not surprising in the light of the structure and in the absence of good horizon markers at critical places. The section obviously involves considerable faulting in addition to the major faulting generally recognized. It is reasonably certain that parts of the formations here represented have been faulted out and equally certain that there has been some duplication of beds.

Our principal interest in this section has been in its production of conodonts. It was hoped that conodont faunas would be found which might aid in the closer correlation of these Oklahoma formations with the better-known Ordovician formations of other regions. It was also hoped that there might be found a zonal distribution which would help in the more certain drawing of close boundaries and therefore assist in the determination of the minor structural features such as duplication and elimination of beds.

In these objectives we have been successful only in part. Conodonts have been found at many horizons in the section, but in most of the samples they are not abundant and the species are commonly not distinctive. Among the numerous fossiliferous zones only four contributed conodonts abundantly; one well down in the McLish, two in the Bromide, and one at the base of the Viola. It is only the last of these, the zone at or near the base of the Viola, that comes close enough to a formation boundary to be helpful in determining its position.

DETAILS OF THE FAUNAS

The detailed descriptions of these Ordovician faunas which follow omit a considerable number of species that are too poorly represented to be identified with reasonable certainty, except in those cases where their omission would present a warped picture of the fauna in other respects than the number of species. It should be understood, therefore, that the forms here considered do not record more than a fair majority of the total number of species that might be reported.

McLISH CONODONT ASSEMBLAGE

The accompanying illustrations of Mc-

Lish conodonts record fourteen species identified with some degree of assurance, and seven others identified less certainly. These are referred to eight genera, two of which, *Pteroconus* and *Oistodus*, are doubtfully represented. A genus of chirognathids is by far the most important numerically and in species. With the exception of two species of *Cordylodus*, one of *Phragmodus*, a trichognathid, and a doubtful specimen of *Oistodus*, all of the McLish assemblage belongs to the fibrous group of conodonts. This distribution, and more particularly the importance of the chirognathid representatives suggest affinities with the Harding sandstone. However, the chirognathids of the Harding all belong to the genus *Chirognathus*, which is not represented in the McLish. Furthermore, *Stereoconus*, *Coleodus*, and *Neocoleodus*, abundant in the Harding, are not represented in the McLish and *Erismodus*, very common in the Harding, is rare in the McLish.

Although Dutchtown[1] conodont assemblages[2] from southeastern Missouri include two species of the new chirognathid genus that are very similar to or identical with McLish species there is little else to suggest a correlation between these two formations and much in the two conodont assemblages to emphasize differences. One of the most striking differences is the great abundance of erismodids and multioistodids in the Dutchtown. The latter group is not known in the McLish and the former is but sparsely represented.

One of the most striking features of the conodonts of the Glenwood beds of Minnesota as made known by Stauffer[3] is the great abundance and variety in the chirognathid group. Eighteen species from the Glenwood have been referred to the genus *Chirognathus*. Most of the species thus referred are more like the group designated by us as a new chirognathid genus than like the typical representatives of *Chirognathus* from the Harding, in that the Minnesota specimens, with few exceptions, have denticles with sharp rather than rounded edges. On the other hand, the Minnesota specimens have a basal facet much like that of *Chirognathus* and the denticles though sharp edged, as in the new genus, are long and slender, as in *Chirognathus*, and the sharp edges are carinae rather than simple compressed sides of the denticles. Other features of the Glenwood fauna show little similarity to those of the McLish.

Little is known as yet regarding differences of conodont faunas to be expected as the result of wide geographic separation, variation in sedimentary environment or differences in age. In the light of intercontinental distributions, as made known by us elsewhere[4], it is reasonable to interpret the marked differences between the three faunas mentioned above as recording the influence of time separation rather than geographic isolation. On the other hand, all three of these faunas, the McLish, the Harding, and the Glenwood, are unique and similar in the remarkable development of the chirognathids, a fact that may well be interpreted as indicating a gross correlation in age. There seems to be some justification in concluding from the conodont evidence that the McLish is slightly younger than the Harding.

STRATIGRAPHIC DISTRIBUTION

The accompanying chart shows the distribution of the most significant species identified in the conodont faunas of the McLish, lower Bromide, upper Bromide, and Viola. Omitted are most of the species that are doubtfully identified and most of those that are confined to one of the four assemblages described. The exceptions are the species of *Leptochirognathus* that occur only in the McLish and a species of this genus

[1] The Dutchtown formation of southeastern Missouri was described by H. S. McQueen (1937). He referred it to Lower Ordovician, just below the Joachim. Whether it is Lower or Middle Ordovician depends on where the line between the two series is drawn. The writers place the boundary below the St. Peter sandstone and as the Dutchtown seems to be above the St. Peter it is lower Middle Ordovician in age.

[2] Though James S. Cullison (1938) listed only five species of conodonts from the Dutchtown, more than 20 species have been collected by the junior author.

[3] Stauffer, Clinton R., 1935, Conodonts of the Glenwood beds: Geol. Soc. America Bull., vol. 36, pp. 123–168, pls. 9–12.

[4] Branson, E. B., and Mehl, M. G., 1941, A record of typical American conodont genera in various parts of Europe: Denison Univ., Sci. Lab. Bull., vol. 35, pp. 189–194, pl. 7.

that occurs only in the lower Bromide. These exceptions are made to emphasize the leptochirognathid nature of the McLish fauna and to record the vertical range of this genus.

There is little in actual species distribution to suggest a close time relationship between the Harding and the McLish and no evidence that would tend to connect the McLlish with the overlying lower Bromide. The latter is to be expected because these two formations are normally separated by the intervening Tulip Creek. The occurrence of two species of *Leptochirognathus*, common to the McLish and Dutchtown, indicates close correlation between those formations.

Omission of species confined to the lower and upper Bromide respectively obscures the differences between these two assemblages but serves to show the similarity between the fauna of the combined Bromide and that of the Joachim.

The similarity between the faunas of the Viola and Plattin is evident.

DISTRIBUTION OF ORDOVICIAN CONODONTS IN OKLAHOMA, MISSOURI, AND COLORADO

	Harding	Dutchtown	McLish	Joachim	L. Bromide	U. Bromide	Plattin	Viola	Kimmswick
Leptochirognathus gracilis			×						
Leptochirognathus erecta			×						
Leptochirognathus extensa					×				
Leptochirognathus obesa			×						
Leptochirognathus prima		×	×						
Leptochirognathus quadrata		×	×						
Leptochirognathus semiflorealis			×						
Leptochirognathus tridactylla			×						
Cordylodus primus	×	×	×						
Cordylodus plattinensis			×				×		
Trucherognathus distorta				×	×				
Trucherognathus irregularis					×		×		
Curtognathus coronata				×	×				
Curtognathus limitaris				×	×	×			
Cardiodus densus				×		×			
Polycaulodus bidentatus					×	×	×		
Polycaulodus tridentatus					×		×		
Microcoelodus asymmetricus				×	×				
Microcoelodus minutidentatus				×	×				
Microcoelodus typus				×	×	×			
Dichognathus extensa							×	×	
Dichognathus typica							×	×	×
Phragmodus primus		×	×						
Phragmodus undatus							×	×	×
Paltodus compressus							×	×	
Paltodus gracilis							×	×	×
Oistodus abundans							×	×	
Oistodus inclinatus							×	×	
Oistodus suberectus						×	×		×

Dutchtown and Kimmswick conodont occurrences are taken from unpublished manuscripts by Kenneth McLaughlin and Frederick Strothmann, formerly graduate students in geology at the University of Missouri.

No significance should be attached to the order of listing of the formations in the accompanying chart.

McLISH CONODONTS

Genus LEPTOCHIROGNATHUS Branson and Mehl, n. gen.

Complex concavoconvex dental units of fibrous structure, palmate in shape, consisting of three to five or more compressed thin, sharp-edged denticles fused into a common base, bilaterally almost symmetrical to markedly asymmetrical; truncated to form a flat, convex, or slightly concave but unexcavated attachment facet.

This genus closely resembles *Chirognathus* differing most evidently in having thin, sharp-edged denticles that tend to fuse laterally as opposed to the more generally discrete denticles with more or less circular cross sections in *Chirognathus*. In *Chirognathus* the attachment is commonly restricted and shallow cup- or saucerlike rather than a beveled edge as in *Leptochirognathus*.

Genotype.—*L. quadrata* Branson and Mehl n. sp.

In all forms of this genus the generally concave side of the piece is designated as the inner side. In cases of marked asymmetry the denticles are assumed to be directed forward and the anterior denticle is designated as the first. In nearly symmetrical forms the lateral denticles are designated as first, second, etc., from the middle toward the ends of the dental unit.

LEPTOCHIROGNATHUS GRACILIS Branson and Mehl, n. sp. Plate 63, figures 39, 40

Dental unit bilaterally asymmetrical, inner face concave longitudinally, ridge near to and paralleling aboral margin. Denticles four, unequal in length and basal width, all inclined forward; first denticle parallel with aboral margin, formed by anterior extension of base of unit, with only short, stout, somewhat rounded free distal end; second denticle short, base narrow, rapidly tapering to sharp point, confluent for half its length or more with first and third denticles, inclined forward at small angle with base; third denticle long, wide at base, rapidly tapering to sharp point, directed forward at small angle with base, confluent along almost entire length with second denticle and base of unit, posterior edge free except close to base; fourth denticle short, stout, posterior edge extending beyond base of unit. Aboral outline straight in lateral view with short orad curve at each extremity. Attachment facet troughlike with rounded extremities, extending with gradually increasing width from well forward on edge of first denticle to greatest width beneath last denticle.

Cotypes.—Univ. Missouri, C530-3.

LEPTOCHIROGNATHUS ERECTA Branson and Mehl, n. sp. Plate 63, figure 18

Dental unit nearly bilaterally symmetrical, general surface of inner face somewhat concave, base much thickened at midlength with ridge slightly above, paralleling inner aboral edge. Denticles four, subequal, one of first laterals commonly slightly larger, all broad at base, confluent proximally for about one-third of length, widely and uniformly divergent, tapering to pointed extremities. Inner and outer aboral edges with slightly sigmoidal curve in direct lateral view, convexities of curve reversed on opposite sides. General plane of attachment beveling aboral edge, conspicuous in inner lateral view. Attachment facet exceptionally broad at midlength, slightly concave, gradually tapering to pointed anterior and posterior extremities that fail to reach ends of tooth.

Holotype.—Univ. Missouri, C528-5.

LEPTOCHIROGNATHUS OBESA Branson and Mehl, n. sp. Plate 63, figures 36–38

Dental unit bilaterally asymmetrical, outer face convex longitudinally, slightly convex vertically, greatly thickened at base. Denticles three, robust; first denticle small, pointed, inclined forward; base wide, originating slightly back of anterior end of unit; second denticle larger than others, sharply

pointed, inclined forward, base exceptionally wide; third denticle of intermediate size, exceptionally thick, bluntly pointed, erect, posterior edge forming right angle with aboral edge of unit, outer edge moderately sharp. Outer aboral edge nearly straight in direct lateral view, inner edge slightly arched near middle. A small part of articular facet visible in direct inner lateral view. Facet slightly concave, widest near midlength, gradually tapering toward ends of base.

Cotypes.—Univ. Missouri, C531-4.

LEPTOCHIROGNATHUS PRIMA
Branson and Mehl, n. sp.
Plate 63, figures 29–35

Dental unit bilaterally asymmetrical, inner face concave, base somewhat thickened. Denticles four, first and fourth subequal, second and third progressively larger, all inclined forward; first denticle forming major part of aboral margin, fourth forming slightly less than right angle with aboral margin; first denticle narrow, thicker than in most species, confluent with second in proximal half or two-thirds of length; second and third denticles broad, sharp pointed, confluent for short distance; fourth denticle narrow, thick, posterior margin rounded, anterior margin moderately sharp from about midlength outward. Aboral outline convex in lateral view, curvature increasing near posterior end. Attachment scar trench-like along half or more of outer margin of first denticle, increasing in width to base of third denticle, beyond it grades into convex surface tapering to point at posterior end of aboral edge.

Holotype.—Univ. Missouri, C529-2.

Occurrence.—McLish, Pontotoc County, Oklahoma; Dutchtown, Cape Girardeau County, Missouri.

LEPTOCHIROGNATHUS QUADRATA
Branson and Mehl, n. sp.
Plate 63, figures 23–28

Dental unit bilaterally asymmetrical, thin, denticles and base curved on inner face. Denticles four, sharply pointed, broad, partially fused proximally, variable in length, first and fourth of nearly equal length, smaller than second and third; first three directed anteriorly, last nearly erect.

EXPLANATION OF PLATE 63
All figures ×23½ unless otherwise stated.
McLish Conodonts

FIGS. *1*—*Erismodus* sp. indet. Inner lateral view of an apical denticle. Univ. Missouri, C528-4. (p. 380)
2—*Pteroconus?* sp. Inner posterolateral view of an incomplete specimen. Univ. Missouri, C529-4. (p. 380)
3—*Curtognathus* sp. Inner lateral view of apical part of arch. Univ. Missouri, C527-2. (p. 381)
4—*Trichognathus?* sp. Posterior view. Univ. Missouri, C528-3. (p. 381)
5—*Leptochirognathus?* sp. Inner view of an incomplete specimen. Univ. Missouri, C527-3. (p. 380)
6—*Cordylodus primus*. Inner lateral view. Univ. Missouri, C528-1. (p. 381)
7—*Cordylodus plattinensis?* Outer lateral view. Univ. Missouri, C527-5. (p. 381)
8—*Phragmodus primus?* Inner lateral view. Univ. Missouri, C527-4. (p. 381)
9—*Oistodus?* sp. indet. Inner lateral view of a broken specimen. Univ. Missouri, C528-2. (p. 381)
10—*Erismodus* sp. indet. Inner lateral view of apical portion. Univ. Missouri, C531-2. (p. 380)
11–16—*Leptochirognathus semiflorealis*, n. sp. Inner and outer lateral views of six specimens. Univ. Missouri, C529-5, C529-1 (figs. 12–15), C530-5 (the holotype). (p. 379)
17, 19–22—*Leptochirognathus tridactyla*, n. sp. Inner lateral views of five specimens. Univ. Missouri, C528-5 (figs. 17, 20, 22), C529-3, C531-3 (the holotype). Figure 19 ×10. (p. 380)
18—*Leptochirognathus erecta* Branson and Mehl, n. sp. Inner lateral view of holotype. Univ. Missouri, C65-3, ×10. (p. 377)
23–28—*Leptochirognathus quadrata*, n. sp. Inner and outer lateral views of six specimens. Univ. Missouri, C527-1, C531-5 (figs. 24–27), C530-2 (the holotype). (p. 378)
29–35—*Leptochirognathus prima*, n. sp. Inner and outer lateral views of seven specimens. Univ. Missouri, C531-1 (figs. 29, 30, 32–35), C529-2 (the holotype). (p. 378)
36–38—*Leptochirognathus obesa*, n. sp. Inner and outer lateral views of three cotypes. Univ. Missouri, C531-4. (p. 377)
39–40—*Leptochirognathus gracilis*, n. sp. Inner and outer lateral views of two cotypes. Univ. Missouri, C530-3. (p. 377)

Branson and Mehl, Ordovician Conodonts

Branson and Mehl, Ordovician Conodonts

Inner aboral edge sigmoidal in direct lateral view, concave anteriorly, slightly convex posteriorly. Attachment facet beveling aboral edge, evident in direct inner lateral view, widest near midlength, faint midwidth groove extending from near tip of pointed extremities.

Holotype.—Univ. Missouri, C530-2.

Occurrence.—McLish, Pontotoc County, Oklahoma; Dutchtown, Cape Girardeau County Missouri.

LEPTOCHIROGNATHUS SEMIFLOREALIS
Branson and Mehl, n. sp.
Plate 63, figures 11–16

Dental unit nearly bilaterally symmetrical, inner face concave, outer face transversely convex. Denticles five, subequal, broad, tapering abruptly to sharp apices, all nearly erect, slightly divergent, laterally fused for half their length proximally. Inner aboral edge nearly straight in direct lateral

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EXPLANATION OF PLATE 64
All figures ×21½.

Lower Viola Conodonts

FIGS. *1*—*Oistodus inclinatus* Branson and Mehl. Inner lateral view. Univ. Missouri, C541-4. (p. 386)
2, 3—*Pteroconus? abbreviatus* Branson and Mehl, n. sp. Outer and inner lateral views of two syntypes. Univ. Missouri, C541-3. (p. 387)
4, 5—*Phragmodus undatus* Branson and Mehl. Inner and outer lateral views of two specimens. Univ. Missouri, C540-3. (p. 386)
6—*Paltodus compressus* Branson and Mehl. Lateral view. Univ. Missouri, C540-4. (p. 386)
7, 8—*Paltodus gracilis* Branson and Mehl. Lateral views of two specimens. Univ. Missouri, C541-1. (p. 386)
9—*Dichognathus typica* Branson and Mehl. Outer lateral view. Univ. Missouri, C524-4. (p. 387)
10—*Dichognathus extensa* Branson and Mehl. Outer lateral view. Univ. Missouri, C541-2. (p. 387)
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Upper Bromide Conodonts

12—*Microcoelodus typus* Branson and Mehl. Posterolateral view of an incomplete specimen. Univ. Missouri, C538-1. (p. 385)
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15—*Polycaulodus bidentatus* Branson and Mehl. Lateral view. Univ. Missouri, C540-2. (p. 385)
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20—*Curtognathus limitaris?* Branson and Mehl. Posterior view. Univ. Missouri, C539-5. (p. 386)
21—*Cardiodus densus* Branson and Mehl. Oral view. Univ. Missouri, C538-5. (p. 385)
22—*Curtognathus* sp. Anterior view. Univ. Missouri, C539-1. (p. 386)

Lower Bromide Conodonts

23–26—*Cardiodus robustus* Branson and Mehl, n. sp. Oral views of four specimens. Univ. Missouri, C537-2, C536-5 (holotype), C535-2, and C533-2. (p. 382)
27, 28—*Polycaulodus tridentatus* Branson and Mehl. Lateral views of two specimens. Univ. Missouri, C534-5. (p. 382)
29—*Polycaulodus bidentatus* Branson and Mehl. Lateral view. Univ. Missouri, C536-2. (p. 382)
30, 33—*Trucherognathus distorta* Branson and Mehl. Oral views of a typical mature specimen and a supposedly immature specimen. Univ. Missouri, C533-4 and C534-3. (p. 385)
31, 32—*Trucherognathus irregularis* Branson and Mehl. Inner lateral and oral views of two specimens. Univ. Missouri, C534-1. (p. 384)
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35, 51, 52—*Leptochirognathus extensa* Branson and Mehl, n. sp. Inner lateral views of three syntypes, a complete lateral bar, Univ. Missouri, C535-5, a chief denticle (C535-5), and a specimen complete except for the terminus of the large bar, Univ. Missouri, C533-5. (p. 383)

(*Continued on next page*)

view, midlength portion produced abruptly inward. Middle part of outer aboral edge produced aborad into tonguelike process sharply offset on inner side from attachment surface proper. Attachment scar slightly concave at midlength, anterior and posterior extensions narrow and pointed.

Holotype.—Univ. Missouri, C530-5.

LEPTOCHIROGNATHUS TRIDACTYLA
Branson and Mehl, n. sp.
Plate 63, figures 17, 19–22

Dental unit nearly bilaterally symmetrical to asymmetrical, only slightly concave on inner side, base thick near midlength, tapering to thin extremities. Denticles three; median denticle erect, largest; lateral denticles widely divergent; all broad at base, tapering to pointed apices, only slightly confluent at proximal ends. Inner aboral edge nearly straight in direct lateral view, outer edge extending aborad slightly at midlength. Aboral part beveled, producing nearly flat attachment scar visible from sides, slightly concave, very broad at midlength, tapering to pointed anterior and posterior extremities.

Holotype.—Univ. Missouri, C531-3.

LEPTOCHIROGNATHUS? sp.
Plate 63, figure 5

Bilaterally nearly symmetrical *Leptochirognathus*-like with large sharp edged median denticle flanked on each side by about three much smaller pointed, somewhat compressed moderately sharp-edged denticles. Aboral edge grooved rather than faceted, inner edge at midlength sharply extended inward.

Figured specimen.—Univ. Missouri, C527-3.

Occurrence.—McLish, Pontotoc County, Oklahoma.

Genus ERISMODUS Branson and Mehl

This genus is sparingly represented in the McLish collections. Fragments that can be identified generically with certainty are few and specimens that are complete enough for specific reference are lacking.

ERISMODUS sp. indet.
Plate 63, figures 1, 10

The erismodids of our McLish collections are represented almost entirely by isolated apical denticles. One type, not identifiable with described species, is slender and somewhat twisted, with the outer aborad process sharp and slightly bent laterally.

Another distinctive type shows a tendency toward a long median denticle with lateral bars sharply arched and bent inward.

Genus PTEROCONUS Branson and Mehl

It is not certain that the McLish fauna includes representatives of *Pteroconus*, but one poorly preserved specimen has been referred tentatively to that genus.

PTEROCONUS? sp.
Plate 63, figure 2

Apical denticle slender, sharply recurved,

FIGS. *36, 54–56—Microcoelodus typus* Branson and Mehl. Posterior, posterior, anterior, and posterior views of four specimens. Univ. Missouri, C533-1. (p. 383)

37, 39, 41, 46—Microcoelodus asymmetricus Branson and Mehl. Inner, inner, and outer lateral views of three specimens and inner lateral view of a small specimen thought to be an early stage of development. Univ. Missouri, C535-4 (figs. 37, 39), C536-3, and C537-4. (p. 383)

38, 40, 53—Microcoelodus intermedius Branson and Mehl, n. sp. Inner, outer, and inner lateral views of three syntypes. Univ. Missouri, C532-1. (p. 384)

42, 43—Cordylodus sp. indet. Inner lateral views of two distinctive types of undetermined affinities. Univ. Missouri, C535-1 and C533-3. (p. 382)

44—Microcoelodus? sp. Inner lateral view of an incomplete specimen of distinctive features, Univ. Missouri, C532-4. (p. 384)

45—Microcoelodus inornatus Branson and Mehl, n. sp. Inner aboral view of the holotype. Univ. Missouri, C535-3. (p. 384)

47—Curtognathus coronata Branson and Mehl. Inner aboral view of an exceptionally large specimen. Univ. Missouri, C532-5. (p. 384)

48—Cardiodus arcuatus Branson and Mehl. Inner lateral view. Univ. Missouri, C534-4. (p. 382)

49—Curtognathus limitaris Branson and Mehl. Inner lateral view. Univ. Missouri, C536-1. (p. 384)

50—Microcoelodus minutidentatus Branson and Mehl. Inner lateral view of an atypical specimen. Univ. Missouri, C532-3. (p. 384)

laterally compressed, aboral side with comparatively small but deep excavation. Lateral bar long, bladelike, denticles three or more, stout, round, discrete. Posterior bar bladelike.

The comparatively small subapical pit of this form makes its generic reference somewhat doubtful.

Genus CURTOGNATHUS Branson and Mehl
CURTOGNATHUS sp.
Plate 63, figure 3

Dental unit nearly symmetrical, base broadly arched. Bar denticles small, closely crowded, somewhat compressed. Apical denticle considerably larger, sharp-edged. All denticles slightly incurved. Aboral side cupped beneath apical denticle.

No complete specimens of this species are known. The fragmentary specimens do not justify specific reference and leave some doubt as to generic identity.

Genus TRICHOGNATHUS Branson and Mehl
TRICHOGNATHUS? sp.
Plate 63, figure 4

Dental unit sharply arched, bars slender, forming apical angle of about 60 degrees. Apical denticle subcircular in cross section with two faint carinae, one anterior, the other anterolateral, sharply recurved, inner basal portion compressed laterally, produced posteriorly, outer basal portion produced somewhat aborad into tonguelike process. Bar denticles short, circular, discrete. Deep aboral excavation beneath apex produced into shallow grooves along lateral bars.

The specimen on which this description is based is too incomplete to justify specific reference but its characters are sufficiently clear to raise the question of generic reference. The tonguelike outer aborad projection is less pronounced than in most of the erismodids but suggests the development in that group rather than in *Trichognathus*.

Genus CORDYLODUS Pander
CORDYLODUS PRIMUS Branson and Mehl
Plate 63, figure 6

Cordylodus primus BRANSON and MEHL, *1933*, Missouri Univ. Studies, vol. 8, p. 35, pl. 1, fig. 35.

One incomplete McLish specimen agrees well with the cotypes (Harding specimens) of this species.

CORDYLODUS PLATTINENSIS?
Branson and Mehl
Plate 63, figure 7

One specimen from the McLish is similar to the cotypes (Plattin specimens) of this species, but its incompleteness prevents certain identification.

Genus PHRAGMODUS Branson and Mehl
PHRAGMODUS PRIMUS? Branson and Mehl
Plate 63, figure 8

A specimen from the McLish agrees well with the cotypes (Joachim specimens) of *Phragmodus primus* but because of its incompleteness the reference is questionable.

Genus OISTODUS Pander
OISTODUS? sp. indet.
Plate 63, figure 9

A poorly preserved dental unit in the McLish suggests the presence of oistodids in that formation. However, the specimen may represent a cordylodid development similar to one trend found in the lower Bromide. For this reason the specimen is referred to the genus *Oistodus* with question.

BROMIDE CONODONTS

The Bromide formation has yielded conodonts sparingly from nearly every part of its total thickness but only two zones have produced them in sufficient number to give a fairly adequate picture of the fauna as a whole. Ignoring the differences between these two producing zones the Bromide conodont fauna has much in common with that from the base of the Joachim formation in east-central Missouri. The conodont fauna of the upper part of the Joachim is markedly different from that of the lower part and is similar to that of the immediately overlying Plattin. Representatives of *Trucherognathus*, *Curtognathus*, *Cardiodus*, *Microcoelodus*, and *Polycaulodus* are the most abundant forms in both the Bromide and the basal Joachim and some of the species are common to both of the formations.

The rarity of *Leptochirognathus* in the

Bromide sets its fauna off sharply from that of the McLish in which this genus predominates.

Of the two Bromide zones that have yielded conodonts abundantly, the first is about 65 feet above what is commonly designated as the base of the formation in this area. The second of the productive zones is about 20 feet below the upper boundary of the Bromide. In the sense that there is a great thickness of limestone, shale, and sandstone separating these two zones it can be said that their conodonts represent the fauna of the lower and the upper Bromide respectively.

The first of these productive zones is a gray to bluish or greenish shale break, ranging from two inches to somewhat more than a foot in thickness, that overlies a massive five-foot member of buff sandy limestone. The fauna from this zone is characterized by the conspicuous development of *Microcoelodus* and *Trucherognathus*, the first of which is lacking and the second only slightly represented in the higher productive zone. *Leptochirognathus* is sparingly represented in the lower fauna but has not been found in the upper. The lower fauna contains a peculiar form, referred to *Cordylodus*, that does not appear in the upper. There is a similarity in the two faunas in their polycaulodids and cardiodids.

Lower Bromide Species

CORDYLODUS sp. indet.
Plate 64, figures 42, 43

Scraps referable to the genus *Cordylodus* are only fairly abundant in the lower Bromide. Only two specimens well enough preserved to suggest specific characters have been found and neither justifies specific assignment. These specimens indicate two varieties neither of which seems close to described species. One of these is greatly expanded inward at the base so as to present a basal excavation almost circular in outline rather than the laterally compressed opening characteristic of most species of the genus. The other specimen has a laterally compressed base of exceptional length. Both bear large round denticles.

CARDIODUS ARCUATUS Branson and Mehl
Plate 64, figure 48

Cardiodus arcuatus BRANSON and MEHL, *1933*, Missouri Univ. Studies, vol. 8, p. 82, pl. 5, fig. 16.

Specimens from the lower Bromide referred to this species show only slight variations from the holotype of *C. arcuatus* (a Joachim specimen).

CARDIODUS ROBUSTUS Branson and Mehl, n. sp.
Plate 64, figures 23–26

Base broadly crescentic, regularly curved to slightly sigmoidal in outline; aboral surface concave with greatest curvature longitudinal. Arch bilaterally asymmetrical in direct lateral view, with apical denticle flanked by two smaller denticles on one side, three on the other; denticles short, blunt, somewhat compressed anteroposteriorly, edges moderately sharp, divergent; apical denticle strongly inclined backward, lateral denticles less inclined.

Holotype.—Univ. Missouri, C536-5.

Occurrence.—Lower Bromide, Pontotoc County, Oklahoma.

There is considerable variation in this species, particularly from young to mature and old specimens. In early stages the apical denticle is relatively long and pointed and it is flanked by one smaller denticle on each side. There seems to be no regular progressive change in the basal outline with age changes but a considerable variation among specimens of the same stage of development.

POLYCAULODUS TRIDENTATUS Branson and Mehl
Plate 64, figures 27, 28

Polycaulodus tridentatus BRANSON and MEHL, *1933*, Missouri Univ. Studies, vol. 8, p. 106, pl. 8, figs. 5–7, 10.

Although specimens from the lower Bromide depart somewhat from the holotype of this species (a Plattin specimen), the differences are no greater than those existing between Plattin specimens referred to *P. tridentatus*.

POLYCAULODUS BIDENTATUS Branson and Mehl
Plate 64, figure 29

Polycaulodus bidentatus BRANSON and MEHL, *1933*, Missouri Univ. Studies, vol. 8, p. 106, pl. 8, figs. 1–3.

One specimen from the lower Bromide is

referred to this species although it has a small extra denticle and its large denticles and base are more robust, less pointed, and relatively shorter than in specimens from the upper Bromide, that are similarly identified, and in the cotypes (Plattin specimens) of *P. bidentatus*.

The lower Bromide specimen is thought to represent an old individual.

LEPTOCHIROGNATHUS EXTENSA
Branson and Mehl, n. sp.
Plate 64, figures 35, 51, 52

Dental unit bilaterally asymmetrical, inner face concave because of slight curvature of denticles, inward thickening of inner side of base, and lateral curvature of the long limb. Denticles about 12, 10 or more constituting one limb; all moderately sharp edged, only slightly convex transversely on outer side, more convex on inner side, tapering rapidly to moderately sharp or rounded points, confluent, excepting apical denticle, for much of length. Short limb consists of one denticle somewhat shorter than longest denticle of other limb, almost completely fused with apical denticle. Long limb concave aborad, denticles regularly decreasing in length toward free end of limb. Apical denticle nearly twice as long as largest of limb denticles, very wide at base, gradually tapering to moderately sharp point, aboral edge extending inward as sharp fold or projection at midwidth of denticle, outer aboral edge produced downward into rounded tonguelike process. Aboral edge moderately wide except for sharp inward expansion, slightly cupped beneath apical denticle, both limbs slightly grooved nearly to their termini.

Syntypes.—Univ. Missouri, C533-5 and C535-5.

This species has an aboral tonguelike projection comparable to that of *L. semiflorealis* but departs markedly from that species in its exceptionally large apical denticle and marked asymmetry. Fragmentary specimens of *L. extensa* are common in the lower Bromide and it may be assumed that the species is a good marker for that zone. This is the youngest recorded species of the genus and it does not resemble closely any of the earlier species. Many of the fragments are attached to white bone-like material that is typically associated with conodonts of the fibrous group. Growth axes, not commonly noted among the fibrous conodonts, are evident in some of the specimens of this species.

LEPTOCHIROGNATHUS? sp.
Plate 64, figure 34

Base short, oval in outline, slightly cupped, major portion occupied by erect, compressed, sharp-edged, pointed denticle, similar but much smaller denticle confluent to half height of smaller denticle. Anteroposterior expansion of base chiefly inward.

Although the specimen departs radically from typical leptochirognathids it is tentatively referred to this genus in the belief that it represents a very young stage in the development of some form comparable to *L. extensa*. Except for the fact that the denticles are partly coalesced and are sharp edged this specimen might be referred to the genus *Polycaulodus*.

MICROCOELODUS TYPUS
Branson and Mehl
Plate 64, figures 36, 54–56

Microcoelodus typus BRANSON and MEHL, *1933*, Missouri Univ. Studies, vol. 8, p. 90, pl. 6, figs. 31, 32.

Lower Bromide specimens of this species vary somewhat among themselves, particularly in the relative length and robustness of the denticles on the lateral bars, but none differs greatly from the holotype (Joachim specimen) of the species.

MICROCOELODUS ASYMMETRICUS
Branson and Mehl
Plate 64, figures 37, 39, 41, 46

Microcoelodus asymmetricus BRANSON and MEHL, *1933*, Missouri Univ. Studies, vol. 8, p. 91, pl. 7, figs. 5, 10, 11, 14, 15.

Specimens of this species from the lower Bromide differ but little from the Joachim specimens referred to *M. asymmetricus* although they vary somewhat among themselves. The chief differences among the specimens from both formations seem to be in the angles, ranging from 90 to about 120 degrees, formed by the longer free bar and main denticle plane with the smaller free bar. In general the lower Bromide speci-

mens are more robust than those from the Joachim.

MICROCOELODUS INTERMEDIUS
Branson and Mehl, n. sp.
Plate 64, figures 38, 40, 53

Microcoelodus sp. BRANSON and MEHL, *1933*, Missouri Univ. Studies, vol. 8, pl. 7, fig. 6.

Dental unit almost bilaterally symmetrical. Main denticle slender, gradually tapering, edges sharp, produced by median off-set of inner face, strongly recurved, outer aboral margin projecting tonguelike below arch, slightly incurved, inner aboral edge flaring sharply inward. Lateral wings short, slender, discrete, each with about three short, moderately robust, incurved, discrete denticles. Aboral side deeply excavated beneath apical denticle.

Syntypes.—Univ. Missouri, C532-1.

No complete specimens of this species are available but the many nearly complete specimens clearly indicate the characteristic details.

MICROCOELODUS? sp.
Plate 64, figure 44

Dental unit almost bilaterally symmetrical, bars slender. Apical denticle of moderate size, sharply edged, strongly incurved, inner basal margin extended, outer basal margin produced into tonguelike process comparable to that of *Erismodus*. Lateral bars bearing four or more stout, blunt, incurved denticles of somewhat varied size.

This form suggests an atypical development of the genus *Erismodus*, but the lateral bars are not so deeply grooved as in that genus and the tonguelike process is not so well developed. No complete specimens of this species are available.

MICROCOELODUS INORNATUS
Branson and Mehl, n. sp.
Plate 64, figure 45

Dental unit bilaterally symmetrical, apical denticle sharp-edged in its proximal half, circular in distal half, blunt, incurved, base strongly expanded inward. Lateral bars subequal, about as high as wide, oral margins rounded, not denticulate. Aboral excavation extending beneath lateral bars.

Holotype.—Univ. Missouri, C535-3.

MICROCOELODUS MINUTIDENTATUS
Branson and Mehl
Plate 64, figure 50

Microcoelodus minutidentatus BRANSON and MEHL, *1933*, Missouri Univ. Studies, vol. 8, p. 94, pl. 7, figs. 8, 9.

A specimen from the lower Bromide is referred to this species without question although it differs considerably from the holotype (a Joachim specimen). The bar denticles of the Bromide specimen are more clean cut and the apical denticle more distinct than in the holotype. The Bromide specimen seems more strongly arched in a direct lateral view because the inward expansion of the cup at the base of tbe apical denticle is more sharply restricted laterally and does not extend as far downward.

CURTOGNATHUS CORONATA
Branson and Mehl
Plate 64, figure 47

Curtognathus coronata BRANSON and MEHL, *1933*, Missouri Univ. Studies, vol. 8, p. 88, pl. 5, fig. 26.

Specimens from the lower Bromide referred to this species are more robust than the holotype (a Joachim specimen) and show more diversity in the direction of the denticles.

CURTOGNATHUS LIMITARIS
Branson and Mehl
Plate 64, figure 49

Curtognathus limitaris BRANSON and MEHL, *1933*, Missouri Univ. Studies, vol. 8, p. 88, pl. 5, figs. 17, 23, 25.

The species as defined is extremely variable. All specimens resemble the cardiodis group in basal outline but have the arched base of the typical curtognathids. The specimens from the lower Bromide come within the range of those from the Joachim referred to this species.

TRUCHEROGNATHUS IRREGULARIS
Branson and Mehl
Plate 64, figures 31, 32

Trucherognathus irregularis BRANSON and MEHL, *1933*, Missouri Univ. Studies, vol. 8, pp. 104–5, pl. 8, fig. 15.

Lower Bromide specimens vary considerably. Most are more robust than the holotype (a Plattin specimen), but agree with it

more closely than with any of the species described from the Joachim.

TRUCHEROGNATHUS DISTORTA
Branson and Mehl
Plate 64, figures 30, 33

Trucherognathus distorta BRANSON and MEHL, *1933*, Missouri Univ. Studies, vol. 8, p. 84, pl. 5, fig. 1.

One specimen from the lower Bromide, referred to this species with some assurance, departs from the typical Joachim form of *T. distorta* in that the denticles are less long and slender, less numerous, and display less diversity in their directions. Another specimen (Univ. Missouri, C534-3) from the lower Bromide, with only six denticles and proportionally much wider and longer basal outline, may be a young individual representing the midlength portion of the adult tooth.

Upper Bromide Species
MICROCOELODUS TYPUS
Branson and Mehl
Plate 64, figure 12

Microcoelodus typus BRANSON and MEHL, *1933*, Missouri Univ. Studies, vol. 8, p. 90, pl. 6, figs. 31, 32.

One incomplete specimen from the upper Bromide is typical of this species.

TRICHOGNATHUS OBTUSA Branson and Mehl, n. sp.
Plate 64, figure 13

Dental unit sharply arched with bars forming angle of about 60 degrees, bilaterally subsymmetrical due to slight twist of apical denticle. Apical denticle slender, moderately long, inner face offset mediad producing sharp lateral edges, strongly recurved, basal part laterally restricted, produced to form short nondenticulate posterior bar. Denticles on lateral bars three or more, short, discrete, moderately pointed, sharp edged, slightly recurved. Aboral side deeply excavated beneath apical denticle, under posterior bar and for short distance along lateral bars.

Holotype.—Univ. Missouri, C538-2.

POLYCAULODUS TRIDENTATUS?
Branson and Mehl
Plate 64, figure 14

The specimen doubtfully referred to *P. tridentatus* is probably immature.

POLYCAULODUS BIDENTATUS
Branson and Mehl
Plate 64, figure 15

Polycaulodus bidentatus BRANSON and MEHL, *1933*, Missouri Univ. Studies, vol. 8, p. 106, pl. 8, figs. 1–3.

This specimen here referred to *P. bidentatus* has a more robust base and proportionally shorter denticles than typical Plattin specimens.

OISTODUS SUBERECTUS Branson and Mehl
Plate 64, figure 16

Oistodus suberectus BRANSON and MEHL, *1933*, Missouri Univ. Studies, vol. 8, p. 111, pl. 9, fig. 7.

One small incomplete specimen from the upper Bromide is referred to this species.

ERISMODUS? sp.
Plate 64, figure 17

One specimen, apparently a nearly complete bar of *Erismodus* or some closely allied genus, doubtfully records this genus in the upper Bromide. The bar is nearly straight with a wide aboral edge, deeply excavated its entire length. The oral edge bears nine or more closely crowded, somewhat compressed, sharp-edged, short, blunt denticles.

CARDIODUS DENSUS Branson and Mehl
Plate 64, figure 21

Cardiodus densus BRANSON and MEHL, *1933*, Missouri Univ. Studies, vol. 8, p. 81, pl. 5, fig. 15.

This specimen from the upper Bromide referred to *C. densus* has a relatively longer base with somewhat gentler curvature of the convex side of the basal outline than the holotype (Joachim specimen).

CARDIODUS ABBREVIATUS Branson and Mehl, n. sp.
Plate 64, figure 18

Base sublachrymiform in outline, inner margin straight, aboral side slightly concave. Denticles typically three, aligned at about midwidth of base, not reaching extremities but continued as low sharp ridge or as additional aborted denticle, compressed, edges and tips sharp, increasing in length toward broad end of base, all slightly

inclined toward convex side of basal outline.

Holotype.—Univ. Missouri, C540-1.

CURTOGNATHUS LIMITARIS?
Branson and Mehl
Plate 64, figure 20

The specimen referred to *C. limitaris* does not simulate closely any of the specimens previously so identified, but it seems to come within the range of variation displayed by the Joachim specimens.

CURTOGNATHUS CORDIFORMIS
Branson and Mehl, n. sp.
Plate 64, figure 19

Basal outline in direct aboral view semicircular or broadly crescentic, inner margin only slightly concave, extremities tapering, outer margin sharply convex. Base moderately arched for this genus, aboral side slightly concave transversely. Denticles five or more, subequal, gradually tapering, nearly circular in cross section, ranging from nearly erect at ends of row to strongly inclined toward convex side of basal outline at midlength.

Holotype.—Univ. Missouri, C538-4.

The holotype of this species is not complete but its characters are evident. Its base, markedly wide at midlength, resembles some forms of the genus *Cardiodus* but is sufficiently arched to exclude the species from that group.

CURTOGNATHUS sp.
Plate 64, figure 22

An incomplete specimen from the upper Bromide indicates a new species of *Curtognathus* with characteristics similar to those of *C. limitaris* but with relatively shorter and more robust denticles. The specimen is too fragmentary to warrant detailed description.

VIOLA CONODONTS

All of the conodonts from the Viola limestone here figured and described were collected from one zone and locality and are probably only a small part of the total Viola fauna. They were obtained from an irregular dark gray clay band, that seems to mark the base of the Viola, about 14 miles south of Ada on State Highway 48. The same locality furnished the Bromide and McLish conodonts.

Five genera represented by 8 species have been identified. No new genera were found and only one new species is recognized. The fauna is typically Plattin although there are no representatives of *Polycaulodus*, *Trucherognathus*, *Curtognathus*, *Microcoelodus*, *Belodus*, or *Cordylodus*, which are fairly well represented in the Plattin. *Pteroconus*, in the Plattin, has a doubtful Viola representative, a single species that may be a very highly modified pteroconid.

Judging from the assemblage of conodonts here recorded, the Viola is near the middle of the Middle Ordovician. It should be remembered, however, that this assemblage is from the base of that formation and it may not be representative of the entire Viola. Actually, it may include a considerable proportion of residual specimens from some unit of preViola age and higher assemblages from the Viola may indicate correlation with appreciably younger formations.

Lower Viola Species

OISTODUS INCLINATUS Branson and Mehl
Plate 64, figure 1

Oistodus inclinatus BRANSON and MEHL, *1933*, Missouri Univ. Studies, vol. 8, p. 110, pl. 9, fig. 8.

OISTODUS ABUNDANS Branson and Mehl
Plate 64, figure 11

Oistodus abundans BRANSON and MEHL. *1933*, Missouri Univ. Studies, vol. 8, p. 109, pl. 9, figs. 11, 17.

PALTODUS COMPRESSUS Branson and Mehl
Plate 64, figure 6

Paltodus compressus BRANSON and MEHL, *1933*, Missouri Univ. Studies, vol. 8, p. 109, pl. 8, fig. 19.

PALTODUS GRACILIS Branson and Mehl
Plate 64, figures 7, 8

Paltodus gracilis BRANSON and MEHL, *1933*, Missouri Univ. Studies, vol. 8, p. 108, pl. 8, figs. 20, 21.

PHRAGMODUS UNDATUS Branson and Mehl
Plate 64, figures 4, 5

Phragmodus undatus BRANSON and MEHL, *1933*,

Missouri Univ. Studies, vol. 8, pp. 115–116, pl. 8, figs. 22–26.

DICHOGNATHUS TYPICA Branson and Mehl
Plate 64, figure 9

Dichognathus typica BRANSON and MEHL, *1933*, Missouri Univ. Studies, vol. 8, p. 113, pl. 9, figs. 27–29.

DICHOGNATHUS EXTENSA Branson and Mehl
Plate 64, figure 10

Dichognathus extensa BRANSON and MEHL, *1933*, Missouri Univ. Studies, vol. 8, p. 114, pl. 9, fig. 21.

PTEROCONUS? ABBREVIATUS Branson and Mehl, n. sp.
Plate 64, figures 2, 3

Cone sharp-edged, curved orad and inward; outer face regularly curved; inner face depressed near lateral margins; base sharply expanded inward. Oral bar short with oral edge produced into short, closely crowded, sharp-edged, pointed denticles; lateral aborad bar aborted, nondenticulate.

Cotypes.—Univ. Missouri, C541-3.

Occurrence.—Basal Viola, Pontotoc County, Oklahoma.

This species resembles *Pteroconus tortus* Branson and Mehl, from the Plattin (Middle Ordovician), but a lateral aborad bar is undeveloped in the latter.

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BIBLIOGRAPHY AND INDEX TO NEW GENERA, SPECIES, AND VARIETIES OF FORAMINIFERA FOR THE YEAR 1940

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THE FOLLOWING bibliography comprises 222 titles of publications devoted exclusively or partly to foraminifera. Publications issued during the year 1940 number 184. For previous years the following titles are added: 4 for 1931, 2 for 1933, 2 for 1934, 1 for 1935, 1 for 1936, 6 for 1937, 5 for 1938, and 17 for 1939.

From the literature of the year 1940 there are listed in the following index: 2 new families, one subfamily, 12 genera, 11 subgenera, 254 species, 41 varieties, 62 forms to which the *nomenclatura aperta* has been applied, 12 homonyms, 12 *nomina nuda*, and 6 *nomina nova*. Nine species and two varieties for the year 1939 are also added.

Of the 295 new species and varieties, erected during 1940, 14 per cent were recorded from Holocene beds, 45 per cent from Tertiary beds, 26 per cent from Cretaceous beds, and 15 per cent from Paleozoic beds. No new forms became known from Ordovician, Silurian, Devonian, Triassic, Liassic and Jurassic beds during 1940.

Compared with previous years (1931 to 1939) there is a great decline in the publication of new forms of Foraminifera noted for the year 1940. This is due partly to the World War, partly to the fact that many of the papers published in belligerent and occupied countries did not reach the writer in time to be scrutinized for this bibliography and index. Any omission brought to the attention of the writer would be highly appreciated.

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Homonyms.—Because the writer's card-index of Foraminifera (left in Palembang, Sumatra) was not available for checking the new names with respect to homonymy, and the "Catalogue of Foraminifera" by Ellis and Messina is not yet sufficiently complete to be used for such a purpose, only a few homonyms can be listed below. In accordance with Articles 11, 34, 35, and 36 of the International Rules of Zoological Nomenclature, the following forms, erected during 1940, herewith regarded as homonyms, should be renamed by their respective authors within due time:

Ammobaculites midwayensis Cushman, preoccupied by Plummer, 1933.

——— *variabilis* Tappan, preoccupied by H. B. Brady, 1884.

DISCOCYCLINIDAE fam. nov., Vaughan and Cole, preoccupied by Tan, 1936.

Elphidium crispum (Linné, 1767) var. *subcrispum* Cushman and McCulloch, preoccupied by Nakamura, 1937.

Flabellina interpunctata von der Marck, 1858, mut. *elongata* Wedekind, preoccupied by Costa, 1855, and by Silvestri, 1898.

——— *ovalis* Wedekind, preoccupied by d'Orbigny, 1850.

——— *rhombica* Wedekind, preoccupied by Marsson, 1878.

HELICOLEPIDINAE (*recte Helicolepidininae*) subfam. nov., Vaughan and Cole, preoccupied by Tan, 1936.

Lepidocyclina (*Isolepidina*) *mauretanica* (Bourcart and David, 1933) var. *minor* Brönnimann, preoccupied by L. Rutten, 1911.

Miogypsina (*Miogypsina*) *mediterranensis* Brönniman, 1940, var. *excentrica* Brönnimann, preoccupied by Tan, 1937.

Nodosaria bifurcata Tappan, preoccupied by d'Orbigny, 1846.

——— *sublineata* Coryell and Rivero, preoccupied by H. B. Brady, 1884.

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Allomorphina whangaia Finlay, **61,** p. 468, pl. 66, figs. 193–197. Upper Cretaceous, New Zealand.

ALMAENA gen. nov., Samoilova, **145,** p. 377. Fam. Rotaliidae. Genotype: *A. taurica* Samoilova, 1940. Lower Oligocene.

——— *taurica* Samoilova, **145,** p. 378, text figs. 1–3. Lower Oligocene, Crimea, USSR.

Alveolina elliptica (Sowerby, 1840) var. *nuttalli* Davies, **48,** p. 219, pl. 12, figs. 1–4. Eocene, Kohat shale, northwest India.

Ammobaculites cuyleri Tappan, **161,** p. 96, pl. 14, fig. 10. Lower Cretaceous, Texas.

——— *howelli* Acosta, **3,** p. 273, pl. 49, fig. 11. Recent, Caribbean Sea, 4–7 fathoms.

——— *josephi* Acosta, **3,** p. 271, pl. 49, figs. 2, 7, 10. Recent, Caribbean Sea, off southern coast of Camaguey, Cuba, 4–7 fathoms.

——— *midwayensis* Cushman, **33,** p. 52, pl. 9, figs. 1, 2. Eocene, Alabama.

——— *morenoi* Acosta, **3,** p. 272, pl. 49, figs. 1, 3, 8. Recent, Caribbean Sea, off southern coast of Cuba, 4–7 fathoms.

——— *testacea* Tappan, **161,** p. 96, pl. 14, fig. 11. Lower Cretaceous, Texas.

——— *variabilis* Tappan, **161,** p. 97, pl. 14, fig. 12. Lower Cretaceous, Texas. [Note: Preoccupied by *Ammobaculites variabilis* (Brady, 1884, *Verneuilina*), according to A. Franke, 1928, Preuss. geol. Landesanstalt. Abh., vol. 111, new series, p. 166, pl. 15, fig. 6.]

——— *woolnoughi* Crespin and Parr, **29,** p. 304, pl. 12, figs. 2, 3. Permian, New South Wales.

Ammodiscus multicinctus Crespin and Parr, **29,** p. 303, pl. 12, fig. 1. Permian, New South Wales.

Ammomarginulina whitneyi Ilkins and Clabaugh, **82,** pl. 267, pl. 1, fig. 1. Cretaceous, Texas.

Amphicoryne prora Finlay, **61,** p. 453, pl. 65, figs. 148, 149. Middle Miocene, New Zealand.

Amphisorus see Marginopora.

Anomalina aotea Finlay, **61,** p. 458, pl. 65, figs. 111–115. Upper Miocene, New Zealand.

[1] The numbers in bold-face type following the author's name in this Index refer to the publications of the preceding Bibliography.

——— *eoglabra* Finlay, **61,** p. 460, pl. 65, figs. 138–140. Lower Oligocene, New Zealand.

——— *eosuturalis* Finlay, **61,** p. 459, pl. 65, figs. 132–137. Upper Eocene, New Zealand.

——— *macraglabra* Finlay, **61,** p. 460, pl. 66, figs. 141–143. Middle Miocene, New Zealand.

——— *miosuturalis* Finlay, **61,** p. 459, pl. 65, figs. 128–131. Miocene, New Zealand.

——— *parvumbilia* Finlay, **61,** p. 461, pl. 66, figs. 157–159. Upper lower Miocene, New Zealand.

——— *pinguiglabra* Finlay, **61,** p. 460, pl. 66, figs. 160–165. Middle Miocene, New Zealand.

——— *plummerae* Tappan, **161,** p. 124, pl. 18, figs. 15, 16. Lower Cretaceous, Texas. [For: *Anomalina petita* Carsey 1926, nom. nud., Texas Univ. Bull. 2612, p. 48; and for: *Anomalina falcata* Plummer, 1931 (non *Truncatulina falcata* Reuss, 1851), Texas Univ. Bull. 3101, p. 202, pl. 14, figs. 7, 8.]

——— *semiteres* Finlay, **61,** p. 459, pl. 65, figs. 123–127. Upper middle Eocene, New Zealand.

——— *spherica* Finlay, **61,** p. 460, pl. 66, figs. 166–171. Lower Pliocene, New Zealand.

——— *subnonionoides* Finlay, **61,** p. 459, pl. 66, figs. 172–180. Middle Miocene, New Zealand.

——— *visenda* Finlay, **61,** p. 458, pl. 65, figs. 116–119. Upper Middle Eocene, New Zealand.

——— *vitrinoda* Finlay, **61,** p. 485, pl. 65, figs. 120–125. Lower Miocene, New Zealand.

Assilina rota Davies, **48,** p. 215, pl. 11, figs. 2, 4, 5, 7, 13. Lutetian, northwest India.

Asterigerina tombigbeensis Cushman and Garrett, **40,** p. 26. Nomen novum for: *A. alabamensis* Cushman and Garrett, 1939 (not Cushman and McGlamery, 1938).

Asterocyclina praestellaris Brönnimann, **16,** p. 30, pl. 1, fig. 6; pl. 2, fig. 19. Ledian, northwest Morocco.

ATHECOCYCLINA subgen. nov., Vaughan and Cole, **171,** in Cushman, **36,** p. 330. Subgenotype *Discocyclina cooki* Vaughan, 1936, Jour. Paleontology, vol. 10, p. 256, pl. 42, figs. 1–6. Subgenus of *Discocyclina* Gümbel, 1868. Fam. Discocyclinidae. Lower Eocene, Mexico, Trinidad, Alabama, Florida.

BARBOURINELLA gen. nov. (nom. nov.), Bermudez, **8,** p. 410. New name for *Barbourina* Bermudez, 1939.

Bifarina tenuilissa Tappan, **161,** p. 118, pl. 18, fig. 9. Lower Cretaceous, Texas.

Bolivina alazanensis Cushman, 1926, var. *hadleyi* Palmer, **123,** p. 298, pl. 51, figs. 7, 8. Upper Oligocene, Cuba.

Bolivinoides doreeni Finlay, **61,** p. 453, pl. 63, figs. 56–58. Santonian, New Zealand.

BORODINIA gen. nov., Hanzawa, **72,** p. 790. Fam. Planorbulinidae. Genotype: *B. septentrionalis* Hanzawa, 1940. Aquitanian, Pacific regions.

——— *septentrionalis* Hanzawa, **72,** p. 790, pl. 42, figs. 10–12. Aquitanian, North Borodino Island, Japan.

Bradyina cribrostomata Rauser and Reitlinger, **137,** p. 51, pl. 8, figs. 4, 5; pl. 9, figs. 4–6; text figs. 14, 16. Carboniferous. Samara, Russia.

BREVAXINA subgen. nov., Schenck and Thompson, **150,** p. 587. Subgenus of *Misellina* Schenck

and Thompson, 1940. Fam. Fusulinidae; Subfam. Verbeekininae. Subgenotype: *Doliolina compressa* Deprat, 1915, Mem. Serv. géol. Indochine, vol. 4, fasc. 1, p. 14, pl. 3, figs. 10–14; text fig. 7. Permian.

Bulimina aspera Cushman and Parker, **44,** p. 44, pl. 8, figs. 18, 19. Upper Cretaceous, Texas. [For: *B. pupoides* Carsey, 1925 (not d'Orbigny, 1846), Texas Univ. Bull. 2612, p. 29, pl. 4, fig. 3; for: *B. obtusa* Cushman and Church, 1929 (not d'Orbigny, 1840), Proc. California Acad. Sci., series 4, vol. 18, p. 531, pl. 39, figs. 17–19; for: *B. subornata* Sandidge, 1932 (not Brady, 1884), Jour. Paleontology, vol. 6, p. 281, pl. 43, fig. 2; for: *B. elongata* Sandidge, 1932 (not d'Orbigny, 1826), Jour. Paleontology, vol. 6, p. 281, pl. 43, fig. 3; and for: *B. quadrata* Cushman and Parker, 1935, pro parte (not Plummer, 1926), Cont. Cushman Lab. Foram. Research, vol. 11, p. 100, pl. 15, figs. 12, 15, and 16 (not figs. 13 and 14)].

——— *bremneri* Finlay, **61,** p. 455, pl. 64, figs. 84–86. Miocene, New Zealand.

——— *eccentrica* Cushman and Parker, **44,** p. 46, pl. 8, fig. 12. Eocene, Texas.

——— *forticosta* Finlay, **61,** p. 455, pl. 64, figs. 77–81. Upper middle Eocene, New Zealand.

——— *kickapooensis* Cole, 1938, var. *pingua* Cushman and Parker, **44,** p. 44, p. 8, figs. 13, 14. Upper Cretaceous, Gulf Coast region, U. S. A.

——— *mapiria* Finlay, **61,** p. 454, pl. 64, fig. 72. Upper Miocene, New Zealand.

——— *marssoni* Cushman and Parker, **44,** p. 46, pl. 8, fig. 17. Upper Cretaceous, Rügen, Germany. [For: *Tritaxia minuta* Marsson, 1878, Mitth. naturf. Ver. Neu-Vorpommern u. Rügen, Jahrb., vol. 10, p. 162, pl. 4, fig. 31; and for: *Bulimina minuta* (Marsson, 1878) in Cushman, 1937, Cushman Lab. Foram. Research Spec. Pub., vol. 7, p. 29.] [Note: This new name is invalid because Kalinin, 1937, Studies in Micropal., Moscow, vol. 1, fasc. 2, on p. 42, pl. 5, figs. 70 and 71, preserves Marsson's species name and describes new representatives of *Bulimina minuta* (Marsson, 1878) from the Upper Cretaceous of the Ural-Emba region in the USSR.]

——— *miolaevis* Finlay, **61,** p. 454, pl. 64, figs. 70, 71. Lower Miocene, New Zealand.

——— *nannina* Tappan, **161,** p. 116, pl. 19, fig. 4. Lower Cretaceous, Texas.

——— *pahiensis* Finlay, **61,** p. 455, pl. 64, figs. 87, 88. Upper middle Eocene, New Zealand.

——— *pectinata* Cushman and Parker, **44,** p. 45, pl. 8, fig. 20. Upper Cretaceous, Texas.

——— *rakauroana* Finlay, **61,** p. 454, pl. 64, figs. 75, 76. Santonian, New Zealand.

——— *scobinata* Finlay, **61,** p. 455, pl. 64, figs. 82, 83. Upper Oligocene, New Zealand.

——— *senta* Finlay, **61,** p. 454, pl. 64, figs. 73, 74. Miocene, New Zealand.

——— *truncanella* Finlay, **61,** p. 455, pl. 64, figs. 89–91. Middle Eocene, New Zealand.

——— *versa* Cushman and Parker, **44,** p. 47, pl. 8, figs. 15, 16. Paleocene, Montian, France.

Camerina barkeri Gravell and M. A. Hanna, **68,** p. 412, pl. 57, figs. 1–6. Eocene, Claiborne, Mississippi.

——— *mississippiensis* Gravell and M. A. Hanna, **68,** p. 413, pl. 57, figs. 7–11. Eocene, Claiborne, Mississippi.

Cancris amplus Finlay, **61,** p. 463, pl. 64, figs. 92–94. Middle Miocene, New Zealand.

——— *brevior* Finlay, **61,** p. 463, pl. 64, figs. 95–98. Lower Miocene, New Zealand.

——— *compressus* Finlay, **61,** p. 463, pl. 64, figs. 99–101. Upper Middle Eocene, New Zealand.

——— *lateralis* Finlay, **61,** p. 463, pl. 64, figs. 105–107. Middle Miocene, New Zealand.

——— *maoricus* Finlay, **61,** p. 464, pl. 64, figs. 102–104. Recent, off Chicken Island, 42 fathoms.

Cassidulina cuneata Finlay, **61,** p. 456, pl. 63, figs. 62–66. Upper Miocene, New Zealand.

——— *galvinensis* Cushman and Frizzell, **39,** p. 43, pl. 8, fig. 10. Oligocene, Washington County, U. S. A.

——— *palmerae* Bermudez and Acosta, **9,** p. 57, pl. 9, figs. 6–8. Recent, Antillean region, 260 fathoms.

CASSIDULINELLA gen. nov., Natland, **118,** p. 570. Fam. Cassidulinidae. Genotype: *C. pliocenica* Natland, 1940. Upper Miocene and Pliocene.

——— *pliocenica* Natland, **118,** p. 570, pl. 69, figs. 5, 6. Upper Pliocene, California.

——— *renulinaformis* Natland, **118,** p. 571, pl. 69, figs. 1–4, 7. Upper Miocene, California.

Chrysalogonium brodermanni Bermudez and Acosta, **9,** p. 56, pl. 9, fig. 3. Recent, Antillean region, 810 fathoms.

——— *pyramidale* Acosta, **2,** p. 4, pl. 1, figs. 4, 5. Recent, Caribbean, off Cuba, 810 fathoms.

——— *ritae* Acosta, **2,** p. 5, pl. 1, figs. 6, 7. Recent, Caribbean, off Cuba, 810 fathoms.

Cibicides amoenus Finlay, **61,** p. 466, described but not figured. Upper Oligocene, New Zealand.

——— *appositus* Finlay, **61,** p. 467, pl. 67, figs. 217–221. Middle Eocene, New Zealand.

——— *catillus* Finlay, **61,** p. 465, pl. 67, fig. 200. Lower Miocene, New Zealand.

——— *collinsi* Finlay, **61,** p. 466, described but not figured. Upper Middle Eocene, New Zealand.

——— *deliquatus* Finlay, **61,** p. 465, described but not figured. Upper Lower Pliocene, New Zealand.

——— *galerus* Finlay, **61,** p. 466, described but not figured. Lower Miocene, New Zealand.

——— *ihungia* Finlay, **61,** p. 465, pl. 67, figs. 201–206. Upper Oligocene, New Zealand.

——— *jugosus* Finlay, **61,** p. 467, pl. 67, figs. 222, 223. Upper Middle Eocene, New Zealand.

——— *mediocris* Finlay, **61,** p. 464, pl. 67, figs. 198, 199. Middle Miocene, New Zealand.

——— *perforatus* Coryell and Rivero, **27,** p. 335, pl. 44, fig. 13. Middle Miocene, Haiti.

——— *robertsonianus* (Brady, 1881) var. *haitiensis* Coryell and Rivero, **27,** p. 335, pl. 44, figs. 4–6. Middle Miocene, Haiti.

——— *scopos* Finlay, **61,** p. 466, pl. 67, figs. 212, 213. Middle Miocene, New Zealand.

——— *sinistralis* Coryell and Rivero, **27,** p. 335, pl. 44, fig. 12. Middle Miocene, Haiti.
——— *turgidus* Finlay, **61,** p. 467, pl. 67, figs. 214–216. Upper Oligocene, New Zealand.
——— *verrucosus* Finlay, **61,** p. 465, pl. 67, figs. 207–209. Lower Oligocene, New Zealand.

CONOTROCHAMMINA gen. nov., Finlay, **61,** p. 448. Fam. Ammodiscidae. Genotype: *C. whangaia* Finlay, 1940. Uppermost Cretaceous.
——— *whangaia* Finlay, **61,** p. 448, pl. 62, figs. 1, 2. Campanian to ?Danian, New Zealand.

Cushmanella primitiva Cushman and McCulloch, **42,** p. 163, pl. 18, figs. 6–8, 10. Recent, Galapagos Islands, 17 fathoms.

Cyclammina grangei Finlay, **61,** p. 448, pl. 62, figs. 3, 4. Eocene, New Zealand.

Cystammina aguayoi Bermudez and Acosta, **9,** p. 56, pl. 9, figs. 1, 2. Recent, Antillean region, 270 fathoms.

Dentalina plummerae Cushman, **33,** p. 57, pl. 10, figs. 7–9, ? 19. Eocene, Alabama.
——— *see* also *Nodosaria.*

Dentalinopsis subquadrata Tappan, **161,** p. 119, pl. 18, fig. 12. Lower Cretaceous, Texas.

DESINOBULIMINA subgen. nov., Cushman and Parker, **45,** p. 19. Subgenus of *Bulimina* d'Orbigny, 1826. Fam. Buliminidae. Subgenotype: *Bulimina auriculata* Bailey, 1851, Smithsonian. Contr., vol. 2, Art. 3, p. 12, figs. 25–27. Recent, western Atlantic.

DIGITINA gen. nov. Crespin and Parr, **29,** p. 306. Fam. Verneuilinidae. Genotype: *D. recurvata* Crespin and Parr, 1940. Permian.
——— *recurvata* Crespin and Parr, **29,** p. 307, pl. 13, figs. 9, 10. Permian, New South Wales.

DISCOCYCLINA subgen. nov., van der Weijden, **175,** p. 15. Subgenus of *Discocyclina* Gümbel, 1868. Fam. Discocyclinidae. Subgenotype: *Discocyclina* (*Discocyclina*) *augustae* van der Weijden, 1940. Eocene (Bartonian).
——— (*Discocyclina*) *augustae* van der Weijden, **175,** p. 23, pl. 1, figs. 4–8; pl. 2, figs. 1, 2; text figs. Bartonian, Biarritz, France. [For: *Orthophragmina pratti* Schlumberger, 1903 (not Michelin, 1846), Bull. Soc. géol. France, ser. 4, vol. 3, p. 274, pl. 8, figs. 2, 3, (not fig. 1)].

DISCOCYCLINIDAE fam. nov. Vaughan and Cole, **171,** in Cushman, **36,** p. 327. Includes genus *Discocyclina* Gümbel, 1868 (1870) and its subgenera, and genus *Pseudophragmina* H. Douvillé, 1923. Eocene. (Note: The family name is preoccupied by Tan Sin Hok, 1936.)

Discorbis midwayensis Cushman, **33,** p. 70, pl. 12, fig. 6. Eocene, Alabama.

Dorothia alabamiensis Cushman, **33,** p. 53, pl. 9, fig. 7. Eocene, Alabama.
——— *elongata* Finlay, **61,** p. 450, pl. 62, figs. 16, 17. Santonian, New Zealand.

Eggerella columna Finlay, **61,** p. 449, pl. 62, figs. 14, 15. Upper Cretaceous, New Zealand.
——— *ihungia* Finlay, **61,** p. 450, pl. 62, figs. 11–13. Lower Miocene. New Zealand.

Ellipsonodosaria plummerae Cushman, **33,** p. 69, pl. 12, figs. 4, 5. Eocene, Alabama. [For: *Nodosaria sagrinensis* Plummer, 1927 (non Bagg, 1912), Univ. Texas Bull. 2644, p. 85, pl. 4, fig. 16.]

Elphidium crispum (Linnè, 1767) var. *subcrispum* Cushman and McCulloch, **42,** p. 176, pl. 20, fig. 6. Recent, Galapagos Islands, 13 fathoms. (Note: The varietal name is preoccupied by *Elphidium subcripsum* Nakamura, 1937, Japan. Jour. Geol. Geogr., vol. 14, p. 139, pl. 11, fig. 8, from the Pliocene of Formosa.)
——— *incertum* (Williamson, 1858) var. *lene* Cushman and McCulloch, **42,** p. 170, pl. 19, fig. 2. Recent, Pacific, 8 fathoms.
——— *pustulosum* Cushman and McCulloch, **42,** p. 176, pl. 20, figs. 7–10. Recent, Galapagos Islands, 9–80 fathoms.
——— *spinatum* Cushman and Valentine, 1930, var. *magnificum* Cushman and McCulloch, **42,** p. 173, pl. 20, figs. 1, 2. Recent, Cupica Bay, Colombia, 12 fathoms.
——— *stimulum* Cushman and McCulloch, **42,** p. 174, pl. 20, figs. 3, 4. Recent, Galapgaos Islands, 15 fathoms.

Endothyra omphalota Rauser and Reitlinger, **137,** p. 42, pl. 7, figs. 7–9; pl. 9, figs. 7, 8; test fig. 13. Carboniferous, Samara, Russia.

Eouvigerina excavata Cushman, **33,** p. 66, pl. 11, fig. 18. Eocene, Alabama.

Eponides kleinpelli Cushman and Frizzell, **39,** p. 42, pl. 8, fig. 11. Oligocene, Washington State, U. S. A.

EUDISCODINA subgen. nov., van der Weijden, **175,** p. 15. Subgenus of *Discocyclina* Gümbel, 1868 (1870). Fam. Discocyclinidae. Subgenotype: *Orthophragmina archiaci* Schlumberger, 1903, Bull. Soc. géol. France, ser. 4, vol. 3, p. 277, pl. 8, figs. 5–7, 11; text fig. c. Lower Eocene.

Fissurina crenulata Coryell and Rivero, **27,** p. 327, pl. 41, fig. 15. Middle Miocene, Haiti.

Flabellina ampullacea Wedekind, **174,** p. 199, pl. 9. fig. 9, 10. Middle Campanian, Westphalia, Germany.
——— *angusta* Wedekind, **174,** p. 197, pl. 9, fig. 33. Lower Campanian, Westphalia, Germany.
——— *caesata* Wedekind, **174,** p. 199, pl. 9, fig. 8. Middle Campanian, Westphalia, Germany.
——— *deltoidea* Wedekind, **174,** p. 186, text fig. 6. Lower Campanian, Westphalia, Germany.
——— ——— ——— mut. *millepunctata* Wedekind, **174,** p. 194, text fig. 10 (not text fig. 9). Lower Campanian, Westphalia, Germany.
——— ——— ——— mut. *pachydisca* Wedekind, **174,** p. 186, text figs. 3, 4. Santonian, Westphalia, Germany.
——— *efferata* Wedekind, **174,** p. 199, pl. 9, figs. 4–7; pl. 11, figs. 10, 11. Middle Campanian, Westphalia, Germany.
——— *interpunctata* von der Marck, 1858, mut. *elongata* Wedekind, **174,** p. 192, pl. 10, fig. 5. Lower Campanian, Westphalia, Germany. [Note: The name of the mutation is preoccupied by *Flabellina elongata* Silvestri, 1898, Mem. Accad. Pont. Nuovi Lincei, vol. 15, p. 226, pl. 3, fig. 7, and also by *Flabellina elongata* (Costa, 1855, *Frondicularia*)].
——— ——— ——— mut. *gibbera* Wedekind, **174,** p. 191, pl. 10, figs. 1–4. Lower Campanian, Westphalia, Germany.

——— *leptodisca* Wedekind, **174,** p. 199, pl. 9, figs. 11–15. Middle Campanian, Westphalia, Germany.
——— *longinqua* Wedekind, **174,** p. 192, text fig. 9. Lower Campanian, Westphalia, Germany.
——— *numismalis* Wedekind, **174,** p. 199, pl. 9, figs. 1–3; pl. 11, figs. 8, 9. Middle Campanian, Westphalia, Germany.
——— *ovalis* Wedekind, **174,** p. 187, text fig. 5. Santonian, Westphalia, Germany. (Note: The species name is preoccupied by *Flabellina ovalis* d'Orbigny, 1850, Prod., vol. 2, p. 185, Upper Cretaceous, France).
——— *praegracilis* Wedekind, **174,** p. 197, pl. 9, fig. 34. Lower Campanian, Westphalia, Germany.
——— *procera* Wedekind, **174,** p. 198, pl. 9, figs. 24–30; pl. 11, figs. 6, 7. Lower Campanian, Westphalia, Germany.
——— *rhombica* Wedekind, **174,** p. 194, pl. 11, fig. 4. Lower Campanian, Westphalia, Germany. [Note: The specific name is preoccupied by *Flabellina reticulata* Reuss, 1851, var. *rhombica* Marsson, 1878, Mitth. naturwiss. Ver. Neu-Vorpommern u. Rügen, vol. 10, p. 140.)].
——— *sphenoidalis* Wedekind, **174,** p. 196, pl. 9, figs. 16–23; pl. 11, fig. 5. Lower Campanian, Westphalia, Germany.
——— ——— ——— mut. *praecursor* Wedekind, **174,** p. 195, pl. 10, fig. 7; text fig. 11. Lower Campanian, Westphalia, Germany.
——— ——— ——— mut. *rostrata* Wedekind, **174,** p. 199, pl. 9, figs. 31, 32. Lower Campanian, Westphalia, Germany.
——— *subulata* Wedekind, **174,** p. 197, pl. 9, fig. 37. Lower Campanian, Westphalia, Germany.
Frondicularia bulbosa Coryell and Rivero, **27,** p. 327, pl. 41, fig. 18. Middle Miocene, Haiti.
——— *midwayensis* Cushman, **33,** p. 63, pl. 10, figs. 34, 35. Eocene, Alabama.
——— *sagittula* vanden Broeck, 1876, var. *cojimarensis* Palmer **123,** p. 285, pl. 53, figs. 7, 8. Upper Oligocene, Cuba.
——— ——— ——— var. *yumuriana* Palmer, **123,** p. 286, pl. 53, figs. 1, 2. Upper Oligocene, Cuba.
Fusulina elegans Rauser and Beljaev, **137,** p. 18, pl. 2, figs. 8–11; text fig. 3. Middle Carboniferous, Samara, Russia.
——— *ozawai* Rauser and Beljaev, **137,** p. 14, pl. 3, figs. 5–8. Middle Carboniferous, Samara, Russia.
——— *samarica* Rauser and Beljaev, **137,** p. 19, pl. 3, figs. 4, 9; pl. 4, figs. 1–3; text fig. 4. Middle Carboniferous, Samara, Russia.
Fusulinella pulchra Rauser and Beljaev, **137,** p. 23, pl. 5, figs. 1–6; text fig. 6. Middle Carboniferous, Samara, Russia.
——— ——— ——— ——— var. *mesopachys* Rauser and Beljaev, **137,** p. 27, pl. 4, figs. 8, 9; text fig. 7. Carboniferous, Samara, Russia.

Gaudryina cushmani Tappan, **161,** p. 99, pl. 15, fig. 6. Lower Cretaceous, Texas.
——— *quadrangularis* Bagg, 1908, var. *antillana* Bermudez and Acosta, **9,** p. 55, pl. 9, figs. 4, 5. Recent, Antillean region, 160 fathoms.
Globigerina circumnodifer Finlay, **61,** p. 469, pl. 66, figs. 150, 151. Upper Cretaceous, New Zealand.
——— *graysonensis* Tappan, **161,** p. 122, pl. 19, figs. 15–17. Lower Cretaceous, Texas.
——— *haitiensis* Coryell and Rivero, **27,** p. 339, pl. 42, figs. 29, 30. Middle Miocene, Haiti.
——— *planispira* Tappan, **161,** p. 122, pl. 19, fig. 12. Lower Cretaceous, Texas.
Gümbelina midwayensis Cushman, **33,** p. 65, pl. 11, fig. 15. Eocene, Alabama.
——— *ototara* Finlay, **61,** p. 453, pl. 63, figs. 50–52. Oligocene, New Zealand.
——— *panikauia* Finlay, **61,** p. 453, pl. 63, figs. 53–55. Santonian, New Zealand.
——— *washitensis* Tappan, **161,** p. 115, pl. 19, fig. 1. Lower Cretaceous, Texas.
Gümbelitria harrisi Tappan, **161,** p. 115, pl. 19, fig. 2. Lower Cretaceous, Texas.
GÜMBELITRIELLA gen. nov., Tappan, **161,** p. 115. Fam. Heterohelicidae. Genotype: *G. graysonensis* Tappan, 1940. Lower Cretaceous.
——— *graysonensis* Tappan, **161,** p. 116, pl. 19, fig. 3. Lower Cretaceous, Texas.
Gyroidina infrafossa Finlay, **61,** p. 462, pl. 64, figs. 181–183. Upper Cretaceous, New Zealand.
——— *loetterlei* Tappan, **161,** p. 120, pl. 19, fig. 10, Lower Cretaceous, Texas. [For: *Pulvinulina* sp. M. Carpenter, 1925, Texas Univ. Bull. 2544, pl. 17, figs. 11, 12; and for: *Gyroidina nitida* Plummer, 1931 (not Reuss, 1844), Texas Univ. Bull. 3101, p. 191, pl. 14, fig. 5.]

HELICOLEPIDINAE subfam. nov. (*recte:* Helicolepidininae), Vaughan and Cole, **171,** in Cushman, **36,** p. 325. New subfamily of Orbitoididae Schubert, 1920. Comprises the genera *Helicolepidina* Tobler, 1922. and *Eulinderina* Barker and Grimsdale, 1936. Middle and Upper Eocene. [Note: This subfamily name is preoccupied by Tan Sin Hok, 1936.]
Hyperammina elegans Rauser and Reitlinger, **137,** p. 55, pl. 8, fig. 11. Lower Carboniferous, Samara, Russia.
——— *vulgaris* Rauser and Reitlinger, **137,** p. 55, pl. 8, figs. 9, 10. Lower Carboniferous, Samara, Russia.

ISODISCODINA subgen. nov., van der Weijden, **175,** p. 15. Subgenus of *Discocyclina* Gümbel, 1868 (1870). Fam. Discocyclinidae. Subgenotype: *Orthophragmina pentagonalis* Deprat, 1905, Soc. géol. France Bull., series 4, vol. 5, p. 507, pl. 18, figs. 24, 25; pl. 19, fig. 27; text fig. G. Eocene (Lutetian).
Isolepidina see Lepidocyclina.

Karreriella (*Karrerulina*) *aegra* Finlay, **61,** p. 451, pl. 62, figs. 21, 22, 25, 26. Danian to lower Middle Eocene, New Zealand.
——— (———) *bortonica* Finlay, **61,** p. 451, pl. 62, figs. 18–20. Middle Eocene to lower Oligocene, New Zealand.
——— (———) *clarentia* Finlay, **61,** p. 451, pl. 62, figs. 23, 24. Turonian, New Zealand.
——— (———) *cushmani* Finlay, **61,** p. 452, pl. 63, figs. 38–42. Upper Oligocene to Middle Miocene, New Zealand.

——— (———) *cylindrica* Finlay, **61,** p. 452, pl. 63, figs. 43–46. Upper Miocene, New Zealand.

——— *subcylindrica* (Nuttall, 1928) var. *caribaea* Acosta, **2,** p. 3, pl. 1, figs. 1–3. Recent, Caribbean, off coast of Cuba, 810 fathoms.

KARRERULINA subgen. nov., Finlay, **61,** p. 450. Subgenus of *Karreriella* Cushman, 1933. Fam. Valvulinidae. Subgenotype: *Gaudryina apicularis* Cushman, 1911, U. S. Nat. Mus., Bull. 71, part 2, p. 69 [=new name for *Gaudryina siphonella* Brady, 1884 (not Reuss, 1851), Challenger Exped., Repts., Zool., vol. 9, pl. 46, figs. 17–19.] Turonian, or earlier, to Recent.

Lagena leptata Tappan, **161,** p. 112. pl. 17, fig. 17. Lower Cretaceous, Texas.

——— *striatifera* Tappan, **161,** p. 112, pl. 17, fig. 18. Lower Cretaceous, Texas.

Lagenammina pyriformis Tappan, **161,** p. 94, pl. 14, figs. 1, 2. Lower Cretaceous, Texas. [For: *Reophax ampullacea* Chapman, 1892 (not Brady, 1884), Jour. Roy. Micr. Soc., p. 320, pl. 5, fig. 2.]

Lagennodosaria extensa Coryell and Rivero, **27,** p. 328, pl. 42, fig. 12. Middle Miocene, Haiti.

——— *sigmoidea* Coryell and Rivero, **27,** p. 328, pl. 42, fig. 9. Middle Miocene, Haiti.

Laticarinina angustata Coryell and Rivero, **27,** p. 333, pl. 43, fig. 15. Middle Miocene, Haiti.

Lenticulina subaculeata (Cushman, 1923) var. *yumuriana* Palmer, **123,** p. 130, pl. 18, fig. 12. Upper Oligocene, Cuba. [For: *?Cristellaria subaculeata* (Cushman, 1923) var. *glabrata* Nuttall 1928 (probably not Cushman), Geol. Soc. London Quart. Jour., vol. 84, p. 90, pl. 6, fig. 5 (not fig. 1)].

Lepidocyclina (*Lepidocyclina*) *claibornensis* Gravell and M. A. Hanna, **68,** p. 414, pl. 57, figs. 12–18. Eocene, Claiborne, Mississippi.

——— (*Isolepidina*) *mauretanica* (Bourcart and David, 1933), var. *minor* Brönnimann, **16,** p. 40, pl. 3, fig. 12; pl. 5, fig. 6. Upper Eocene, Ledian, northwest Morocco. [Note: The varietal name is preoccupied by *Lepidocyclina sumatrensis* (Brady, 1875) var. *minor* Rutten, 1911, K. Akad. Wetensch. Amsterdam Verh. vol. 19, p. 1158].

——— (*Nephrolepidina*) *plicomargo* Hanzawa, **72,** p. 786, pl. 41, figs. 1–5. Aquitanian, North Borodino Island, Japan.

——— (*Isolepidina*) *sarsarica* Brönnimann, **16,** p. 40, pl. 3, fig. 9; pl. 5, fig. 9; pl. 6, fig. 8. Upper Eocene, Ledian, northwest Morocco.

——— (*Nephrolepidina*) *thalmanni* Yabe and Hanzawa, in Hanzawa, **72,** footnote p. 785. Miocene, East Borneo. [For: *Lepidocyclina* (*Nephrolepidina*) *angulosa* H. Douvillé, 1912 (not Provale, 1909) Geol. Reichs-Mus. Leiden Samml., ser. 1, vol. 8, pl. 21, figs. 4, 5; for: *L. angulosa* Rutten, 1915 (not Provale, 1909), Geol. Reichs-Mus. Leiden Samml., series 1, vol. 9, p. 291, pl. 21, figs. 1–4; and for: *L.* (*Nephrolepidina*) cf. *douvillei* Yabe and Hanzawa, 1922 (not Prever, 1905), Japan. Jour. Geol. Geogr., vol. 1, p. 49, pl. 5, fig. 4; pl. 7, figs. 1, 7.]

Lingulina lamellata Tappan, **161,** p. 106, pl. 16, fig. 19. Lower Cretaceous, Texas.

——— *serrata* Tappan, **161,** p. 107, pl. 16, fig. 22. Lower Cretaceous, Texas.

——— *tricrenata* Coryell and Rivero, **27,** p. 328, pl. 41, fig. 12. Middle Miocene, Haiti.

Listerella cojimarensis Palmer, **123,** p. 123, pl. 18, fig. 5. Upper Oligocene, Cuba.

——— *laevis* Cushman, **33,** p. 54, pl. 9, fig. 8. Eocene, Alabama.

Lituola edwardsensis Ikins and Clabaugh, **82,** p. 267, pl. 1, fig. 2. Cretaceous, Texas.

Marginopora anomala Lacroix, **98,** p. 12, text figs. 3–8. Recent, Bay of Cauda, Indochina.

——— (*Amphisorus*) *hemprichi* (Ehrenberg, 1839) var. *subplicata* Lacroix, **98,** p. 15. Not figured. Recent, Bay of Cauda, Indochina. (Note: The species name is erroneously spelled "*kemprichi*" throughout this paper.)

Marginulina cubana Palmer, **123,** p. 278, pl. 52, fig. 18. Upper Oligocene, Cuba.

——— *howeana* Coryell and Rivero, **27,** p. 329, pl. 41, fig. 13. Middle Miocene, Haiti. (Note: *Cave Marginulina howei* Garrett and Ellis, 1937.)

——— *papillata* Coryell and Rivero, **27,** p. 329, pl. 43, fig. 6. Middle Miocene, Haiti.

Massilina planoconvexa Tappan, **161,** p. 100, pl. 15, fig. 8. Lower Cretaceous, Texas.

Miogypsina basraensis Brönniman, **16,** p. 86, pl. 6, figs. 2, 4; pl. 8, figs. 13–17; text figs. 27, 28. Miocene, Burdigalian, northwest Morocco. [For: *M. irregularis* Bourcart and David, 1933 (non Michelotti, 1841), Soc. sci. nat. Maroc Mém., vol. 37, p. 51, pl. 10, figs. 1, 3; pl. 12, figs. 11, 12; text fig. 5; for: *M.* (*Miogypsina*) cf. *irregularis* (Michelin) in Barker and Grimsdale, 1937, Annales Mag. Nat. History, ser. 10, vol. 19, p. 163, pl. 5, figs. 4, 5, 7–10; pl. 7, figs. 2, 3; and for: *M. irregularis* David-Sylvain, 1937 (non Michelin, 1841), Soc. géol. France Mém., vol. 15, no. 33, p. 21, pl. 2, fig. 7.]

——— (*Miogypsinoides*) *complanata* (Schlumberger, 1900) var. *mauretanica* Brönnimann, **16,** p. 77, pl. 7, figs. 7–14; pl. 8, fig. 18; pl. 9, figs. 1, 2; pl. 11, figs. 9–17; text figs. 18–20. Oligocene, Chattian, northwest Morocco.

——— (*Miogypsina*) *mediterranea* Brönnimann, **16,** p. 94, pl. 6, figs. 5, 10, 11; pl. 8, figs. 23, 24; pl. 9, fig. 11; pl. 10, figs. 1–4; pl. 11, figs. 2, 3, 5–7; text figs. 32–34. Miocene, Burdigalian, northwest Morocco.

——— (———) *mediterranea* Brönnimann, 1940, var. *excentrica* Brönnimann, **16,** p. 98, pl. 6, figs. 12–16; pl. 8, figs. 12, 25; pl. 9, figs. 3, 10, 12; pl. 10, figs. 5, 12; text figs. 35–37. Miocene, Burdigalian, northwest Morocco. [Note: The varietal name is preoccupied by *Miogypsina* (*Miolepidocyclina*) *excentrica* Tan, 1937, De Ing. in Nederl.-Indie, vol. 4, part 4, p. 40, pl. 1, fig. 12; pl. 2, figs. 1–7, ?8, 9; pl. 3, figs. 1–9, from the upper Aquitanian of Madura.]

MIOGYPSINELLA gen. nov., Hanzawa, **72,** p. 770. Fam. Miogypsinidae. Genotype: *M. borodinensis* Hanzawa, 1940. Chattian, Pacific Region. (Note: The genus name was published as a *nomen nudum*, by Hanzawa, 1938, Imp. Acad. Tokyo Proc., vol. 14, p. 389.)

——— *borodinensis* Hanzawa, **72,** p. 779, pl. 39, figs. 1–9; text fig. 2. Oligocene, Chattian, North Borodino Island, Japan. (Note: This genotype was published as a *nomen nudum* by Hanzawa, 1938, Imp. Acad. Tokyo Proc., vol. 14, p. 389.)

——— *sanjosensis* Hanzawa, **72,** p. 766, text fig. 3. [For: *Miogypsina complanata* Nuttall, 1933 (not Schlumberger, 1900), Jour. Paleontology, vol. 7, p. 176, pl. 24, figs. 9, 11–14 (not fig. 7); for: *Miogypsina complanata* Barker and Grimsdale, 1937 (not Schlumberger, 1900), Annales Mag. Nat. History, ser. 10, vol. 19, p. 162, pl. 5, fig. 6; pl. 6, figs. 1–6, 8; pl. 7, fig. 1; pl. 8, fig. 6; and for: *?Miogypsina complanata* Silvestri, 1929 (not Schlumberger, 1900), Soc. geol. italiana Boll., vol. 48, p. 210 (figured already in vol. 42 (1923) on pl. 1, fig. 10).] Upper Oligocene, Aquitanian, Mexican Gulf, Caribbean and Mediterranean regions.

MIOGYPSINIDAE fam. nov., Vaughan and Cole, **171,** in Cushman, **36,** p. 330. Includes the genera *Miogypsina* Sacco, 1893; *Miogypsinoides* Yabe and Hanzawa, 1928, and the subgenus *Miolepidocyclina* Silvestri, 1907. Oligocene, Miocene, Pliocene, Europe, America, East Indies.

Miogypsinoides dehaarti (van der Vlerk, 1924) var. *pustulosa* Hanzawa, **72,** p. 780, pl. 40, figs. 9–29; pl. 42, fig. 13; text fig. 5 for megalospheric forms; and pl. 39, fig. 20; pl. 40, figs. 2–8, for microspheric forms. Upper Oligocene, Aquitanian, North Borodino Island, Japan.

——— *lateralis* Hanzawa, **72,** p. 783, pl. 39, figs. 10–14. Upper Oligocene, Aquitanian, North Borodino Island, Japan.

MIOGYPSINOPSIS gen. nov., Hanzawa, **72,** p. 773. Fam. Miogypsinidae. Genotype: *Miogypsina gunteri* Cole, 1938, Florida Geol. Bull. no. 16, p. 42, pl. 6, figs. 10–12, 14; pl. 8, figs. 1–9. Aquitanian (Upper Oligocene).

MISELLINA gen. nov., Schenck and Thompson, **150,** p. 587. Fam. Fusulinidae; subfam. Verbeekininae. Genotype: *Doliolina ovalis* Deprat, 1915, Service géol. Indochine Mém., vol. 4, fasc. 1, p. 15, pl. 3, figs. 1–4; text fig. 9. Permian.

MISELLINA subgen. nov., Schenck and Thompson, **150,** p. 587. Subgenus of *Misellina* Schenck and Thompson, 1940 (ut supra). Subgenotype: *Doliolina ovalis* Deprat, 1915 (ut supra). Fam. Fusulinidae; subfam. Verbeekininae. Permian.

Neobulimina minima Tappan, **161,** p. 117, pl. 19, figs. 5, 6. Lower Cretaceous Texas.

Nephrolepidina see Lepidocyclina.

Nodogenerina obsoleta Acosta, **2,** p. 5, pl. 1, fig. 8. Recent, Caribbean Sea, off coast of Cuba, 810 fathoms.

Nodosaria bifurcata Tappan, **161,** p. 103, pl. 16, fig. 5. Lower Cretaceous, Texas. [Note: The species name is preoccupied by *Nodosaria* (*Dentalina*) *bifurcata* d'Orbigny, 1846, according to Wick, 1939, Preuss. geol. Landesanstalt Jahrb., vol. 59, p. 495, pl. 21, fig. 11.]

——— *chapmani* Tappan, **161,** p. 103, pl. 16, figs. 9, 10. Lower Cretaceous, Texas. [For: *N. orthopleura* Chapman, 1893 (non Reuss, 1863), Royal Micr. Soc. Jour., p. 595, pl. 7, figs. 22, 23; for: *N. prismatica* Reuss, 1860, var. *orthopleura* Reuss, in Franke, 1928, Preuss. geol. Landesanstalt Abh., new ser., vol. 111, p. 48, pl. 4, fig. 12; and for: *N. orthopleura* Reuss, in Eichenberg, 1933, Niedersächs. geol. Ver. Hannover, vol. 25, p. 4, pl. 5, fig. 5.]

——— *hadleyi* Palmer, **123,** p. 280, pl. 52, fig. 2. Upper Oligocene, Cuba. [For: *?Dentalina elegantissima* Hadley, 1934 (not d'Orbigny, 1846), Bulls. Am. Paleontology, vol. 20, no. 70A, p. 10, pl. 1, fig. 19.]

——— *helicata* Coryell and Rivero, **27,** p. 330, pl. 42, figs. 7, 8. Middle Miocene, Haiti.

——— (*Dentalina*) *majzoni* Jaskó, **88,** a new species described and figured from the Stampian of Hungary. (Publication not seen.)

——— (*?*) *multicostales* Finlay, **61,** p. 452, pl. 63, fig. 48. Lower Pliocene, New Zealand.

——— *sinalata* Finlay, **61,** p. 452, pl. 63, fig. 49. Lower Pliocene, New Zealand.

——— *sublineata* Coryell and Rivero, **27,** p. 331, pl. 42, fig. 2. Middle Miocene, Haiti. (Note: The species name is preoccupied by *N. hispida* d'Orbigny, 1846, var. *sublineata* Brady, 1884, Rept. Challenger, vol. 9, Zool., p. 508, pl. 63, figs. 19–22.)

——— *subtetragona* Finlay, **61,** p. 452, pl. 63, fig. 47. Miocene, New Zealand.

Nonion hancocki Cushman and McCulloch, **42,** p. 159, pl. 17, figs. 4, 5. Recent, off coast of Peru, 30–40 fathoms.

——— *iota* Finlay, **61,** p. 456, pl. 65, figs. 108–110. Upper middle Eocene, New Zealand.

Nonionella basiloba Cushman and McCulloch, **42,** p. 162, pl. 18, fig. 3. Recent, Pacific, off coast of California, 50 fathoms.

——— *decora* Cushman and McCulloch, **42,** p. 160, pl. 17, figs. 11, 12. Recent, Galapagos Islands.

——— *japonica* (Asano, 1938) var. *mexicana* Cushman and McCulloch, **42,** p. 160, pl. 17, fig. 10. Recent, Pacific, off coast of Mexico, 53 fathoms.

——— *magnalingua* Finlay, **61,** p. 456, pl. 65, figs. 144, 146. Middle Miocene, New Zealand.

——— *satiata* Finlay, **61,** p. 457. Described but not figured. Middle Miocene, New Zealand.

——— *tanumia* Finlay, **61,** p. 457. Described but not figured. Upper Cretaceous, New Zealand.

——— *zenitens* Finlay, **61,** p. 457, pl. 65, figs. 145, 152–156. Upper middle Eocene, New Zealand.

Nummulites pinfoldi Davies, **48,** p. 209, pl. 10, figs. 1–6, 8. Eocene, Kohat shale, northwest India.

Nuttallides tholus Finlay, **61,** p. 462, pl. 63, figs. 67–69. Santonian, New Zealand.

ORBITOSIPHON gen. nov., Rao, **132,** p. 414. Fam. Orbitoididae. Genotype: *Lepidocyclina* (*Polylepidina*) *punjabensis* Davies, 1937, India Geol. Survey Mem., new ser., vol. 24, no. 1, p. 53, pl. 7, figs. 1–8, 14, 16; text fig. 3. Eocene.

Palaeopolymorphina izawai Tappan, **161,** p. 113, pl. 17, figs. 20, 21. Lower Cretaceous, Texas.
Palmula caribbaea Palmer, **123,** p. 287, pl. 53, figs. 5, 6. Upper Oligocene, Cuba.
——— *cubana* Palmer, **123,** p. 287, pl. 52, figs. 15, 16. Upper Oligocene, Cuba.
Parafusulina aghilensis Reichel, **138,** p. 101, pl. 19, figs. 7–11. Upper Uralian, Karakorum, India.
——— *japonica* (Gümbel, 1883) var. *cincta* Reichel, **138,** p. 106, pl. 22, figs. 1, 2, 5–7. Upper Artinskian, Karakorum, India.
——— (———) var. *densa* Reichel, **138,** p. 108, pl. 23, fig. 2. Upper Artinskian, Karakorum, India.
——— *saksgamensis* Reichel, **138,** p. 109, pl. 21, figs. 1, 2; pl. 23, figs. 3–9. Upper Artinskian, Karakorum, India.
——— *visseri* Reichel, **138,** p. 112, pl. 24, figs. 1, 2. Upper Artinskian, Karakorum, India.
——— ——— ——— var. *lata* Reichel, **138,** p. 114, pl. 24, figs. 3, 4. Upper Artinskian, Karakorum, India.
PARVICARININA gen. nov., Finlay, **61,** p. 468. Fam. Discorbidae. Genotype: *Truncatulina tenuimargo* Brady, 1884, var. *alto-camerata* Heron-Allen and Earland, 1922, Terra Nova Exped., Zool., vol. 6, no. 2, p. 209, pl. 7, figs. 24–27. Lower Oligocene to Recent.
——— *deflata* Finlay, **61,** p. 468. Described but not figured. Lower Miocene, New Zealand.
Placopsilina longa Tappan, **161,** p. 100, pl. 15, figs. 9, 10. Lower Cretaceous, Texas.
Plectofrondicularia (*?*) *yumuriana* Palmer, **123,** p. 294, pl. 53, figs. 3, 4. Upper Oligocene, Cuba.
Planularia cushmani Palmer, **123,** p. 131, pl. 18, fig. 7. Upper Oligocene, Cuba. [For: *Planularia sp.* (*?*) Cushman, 1930, Florida Geol. Survey, Bull. 4, p. 26, pl. 4, fig. 6.]
——— *torrei* Palmer, **123,** p. 277, pl. 51, figs. 5, 6. Upper Oligocene, Cuba.
Polymorphina frondea (Cushman, 1922) var. *yumuriana* Palmer, **123,** p. 288, pl. 51, fig. 9. Upper Oligocene, Cuba.
PROPOROCYCLINA subgen. nov., Vaughan and Cole, **171,** in Cushman, **36,** p. 330. Subgenus of *Pseudophragmina* H. Douvillé, 1923. Subgenotype: *Discocyclina perpusilla* Vaughan, 1929, Proc. U. S. Nat. Mus., vol. 76, art. 3, p. 9, pl. 2, figs. 3–5. Fam. Discocyclinidae. Middle and Upper Eocene.
Pseudofusulina baschkirica Korzhenevsky, **94,** p. 10, pl. 2, figs. 9–13. Lower Permian, Russia.
——— *blochini* Korzhenevsky, **94,** p. 23, pl. 5, figs. 9, 10; pl. 6, figs. 1–6. Lower Permian, Russia.
——— ——— ——— var. *bellatula* Korzhenevsky, **94,** p. 25, pl. 6, figs. 7–10. Lower Permian, Russia.
——— *callosa* Rauser-Cernoussova, **136,** p. 88, pl. 5, figs. 5–7. Permian, Ural region, Russia.
——— *composita* Korzhenevsky, **94,** p. 15, pl. 3, figs. 11–15. Lower Permian, Russia.
——— *declinata* Korzhenevsky, **94,** p. 16, pl. 4, figs. 1–7. Lower Permian, Russia.
——— *decurta* Korzhenevsky, **94,** p. 13, pl. 3, figs. 6–10. Lower Permian, Russia.
——— *ishimbajevi* Korzhenevsky, **94,** p. 7, pl. 2, figs. 1–6. Lower Permian, Russia.
——— ——— ——— var. *correcta* Korzhenevsky, **94,** p. 9, pl. 2, figs. 7, 8. Lower Permian, Russia.
——— *juresanensis* Rauser-Cernoussova, **136,** p. 91, pl. 6, figs. 3–7. Permian, Urals region, Russia.
——— *karagasensis* Rauser-Cernoussova, **136,** p. 89, pl. 5, figs. 9, 10; pl. 6, figs. 1, 2. Permo-Carboniferous, Urals region, Russia.
——— *krotowi* (Schellwien, 1908) var. *globulus* Rauser-Cernoussova, **136,** p. 79, pl. 1, figs. 8–11. Upper Carboniferous, Urals region, Russia.
——— ——— (———) var. *caudata* Rauser-Cernoussova, **136,** p. 80, pl. 1, figs. 12, 13. Upper Carboniferous, Urals region, Russia.
——— *kutkanensis* Rauser-Cernoussova, **136,** p. 90, pl. 6, figs. 8–10. Permian, Urals region, Russia.
——— *lutuginiformis* Rauser-Cernoussova, **136,** p. 83, pl. 2, figs. 11, 12; pl. 3, figs. 1–6. Upper Carboniferous, Urals region, Russia. (For: *Pseudofusulina gregaria* Chen, 1934, Palaeontologia Sinica, ser. B, vol. 4, fasc. 2, pl. 8, fig. 9.)
——— ——— ——— var. *pointeli* Rauser-Cernoussova, **136,** p. 84, pl. 3, figs. 7–10. Upper Carboniferous, Urals region, Russia.
——— *paragregaria* Rauser-Cernoussova, **136,** p. 81, pl. 2, figs. 4–7. Upper Carboniferous, Urals region, Russia.
——— ——— ——— var. *ascendens* Rauser-Cernoussova, **136,** p. 82, pl. 2, figs. 8–10. Upper Carboniferous, Urals region, Russia.
——— *plicatissima* Rauser-Cernoussova, **136,** p. 87, pl. 4, figs. 5, 6; pl. 5, figs. 1–3. Permian, Urals region, Russia.
——— ——— ——— var. *irregularis* Rauser-Cernoussova, **136,** p. 87, pl. 5, figs. 4, 8. Permian, Urals region, Russia.
——— *rauserae* Korzhenevsky, **94,** p. 12, pl. 3, figs. 1–5. Lower Permian, Russia.
——— *sulcata* Korzhenevsky, **94,** p. 5, pl. 1, figs. 1–13. Lower Permian, Russia.
——— *urdalensis* Rauser-Cernoussova, **136,** p. 85, pl. 3, figs. 11, 12; pl. 4, figs. 1, 2, 7. Permian, Urals region, Russia.
——— ——— ——— var. *abnormis* Rauser-Cernoussova, **136,** p. 86, pl. 4, figs. 3, 4. Permian, Urals region, Russia.
Pseudoglandulina scotti Tappan, **161,** p. 105, pl. 16, fig. 13. Lower Cretaceous, Texas.
——— *trochoformis* Coryell and Rivero, **27,** p. 331, pl. 42, figs. 13, 14. Middle Miocene, Haiti.
Pseudopolymorphina roanokensis Tappan, **161,** p. 113, pl. 17, figs. 22, 23, 25. Lower Cretaceous, Texas.
Pulvinulinella acutimarginata Finlay, **61,** p. 462, pl. 66, figs. 184–186. Upper Cretaceous, New Zealand.
——— *creta* Finlay, **61,** p. 463, pl. 64, figs. 187–192. Upper Cretaceous, New Zealand.
Pyrulina longa Tappan, **161,** p. 114, pl. 18, fig. 2. Lower Cretaceous, Texas.

Rectobolivina hangaroana Finlay, **61,** p. 453, pl. 63, figs. 59–61. Upper Miocene, New Zealand.
Rectogümbelina alabamensis Cushman, **33,** p. 65, pl. 11, fig. 16. Eocene, Alabama.

Reophax deckeri Tappan, **161,** p. 94, pl. 14, fig. 3. Lower Cretaceous, Texas.
——— *mariae* Acosta, **3,** p. 270, pl. 49, figs. 4–6. Recent, Caribbean Sea, off south coast of Cuba, 7 fathoms.
——— *minuta* Tappan, **161,** p. 94, pl. 14, fig. 4. Lower Cretaceous, Texas.
Reussella yumuriana Palmer, **123** (erroneously spelled "*Reusella*"), p. 303, pl. 52, figs. 9, 10. Upper Oligocene, Cuba.
Robulus oblongus Coryell and Rivero, **27,** p. 332, pl. 43, fig. 12. Middle Miocene, Haiti.

SAMARINA gen. nov. Rauser and Reitlinger, **137,** p. 53. Fam. Nonionidae. Genotype: *S. operculata* Rauser and Reitlinger, 1940. Lower Carboniferous.
——— *operculata* Rauser and Reitlinger, **137,** p. 53, pl. 8, figs. 7, 8; pl. 9, figs. 12–14; text figs. 17, 18. Lower Carboniferous, Samara, Russia.
Saracenaria cushmani Tappan, **161,** p. 106, pl. 16, fig. 17. Lower Cretaceous, Texas. [For: *Cristellaria sulcifera* Chapman, 1893 (not Reuss, 1863), Jour. Roy. Micr. Soc., p. 650, pl. 10, fig. 2.]
Schackoina primitiva Tappan, **161,** p. 123, pl. 18, fig. 14. Lower Cretaceous, Texas.
Siphotextularia ihungia Finlay, **61,** p. 449, pl. 62, figs. 7, 8. Lower Miocene, New Zealand.
——— *kreuzbergi* Finlay, **61,** p. 449, pl. 62, figs. 5, 6. Lower to Middle Miocene, New Zealand. [For: *Bolivina hantkeniana* Kreuzberg, 1930 (not Brady, 1881), N. Jahrb. Min. etc., Abt. B, Beilage-Band, vol. 64, p. 278, pl. 20, fig. 6.]
——— *subcylindrica* Finlay, **61,** p. 449, pl. 62, figs. 9, 10. Upper Miocene, New Zealand.
Sorites variabilis Lacroix, **98,** p. 7, text figs. 1, 2. Recent, Bay of Cauda, Indochina.
——— *hofkeri* Lacroix, **98,** p. 10. Described but not figured. (For: *Praesorites orbitolinoides* Hofker, 1930.)
Sphaeroidinella disjuncta Finlay, **61,** p. 469, pl. 67, figs. 224–228. Lower Miocene, New Zealand.
Spiroplectammina ammovitrea Tappan, **161,** p. 97, pl. 14, fig. 13. Lower Cretaceous, Texas.
Stensiöina americana Cushman and Dorsey, **38,** p. 5, pl. 1, fig. 7. Upper Cretaceous, Texas. [For: *Cibicides excolata* Cushman, 1931 (not *Truncatulina excolata* Cushman, 1926), Jour. Paleontology, vol. 5, p. 315, pl. 36, fig. 8; and for: *Stensiöina excolata* Cole, 1938 (non Cushman, 1926), Florida Geol. Survey, Bull. 16, p. 35, pl. 3, figs. 2, 3.]
——— *labyrinthica* Cushman and Dorsey, **38,** p. 3, pl. 1, fig. 5. Upper Cretaceous, Galicia. [For: *?Gyroidina exsculpta* Macfadyen, 1932 (not Reuss, 1860), Geol. Magazine, vol. 69, pl. 35, fig. 26.]
Streblus aoteanus Finlay, **61,** p. 461. Described but not figured. New Zealand, Pliocene to Subrecent.

Textularia astutia Lalicker and McCulloch, **102,** p. 119, pl. 13, fig. 4. Recent, Pacific, off coast of Lower California (Mexico), 30 fathoms.
——— *aura* Lalicker and McCulloch, **102,** p. 119, pl. 13, fig. 5. Recent, Gulf of Guayaquil, Ecuador, 12 fathoms.
——— *calva* Lalicker, 1935, var. *cojimarensis* Palmer, **123,** p. 113, pl. 17, figs. 1, 2. Upper Oligocene, Cuba.
——— *carinata* d'Orbigny, 1846, var. *mucronata* Jaskó, **88,** described and figured from Stampian beds of Hungary. (Publication not seen.)
——— *lancea* Lalicker and McCulloch, **102,** p. 130, pl. 14, fig. 14. Recent, off Galapagos Islands, 111 fathoms.
——— *lauta* Lalicker and McCulloch, **102,** p. 130, pl. 15, fig. 15. Recent, Darwin Bay, Galapagos Islands, 17 fathoms.
——— *orbica* Lalicker and McCulloch, **102,** p. 136, pl. 15, fig. 17. Recent, off Galapagos Islands, 111 fathoms. (For: *T. trochus* Brady, 1884, Rept. Challenger Exped., vol. 9, Zool., p. 366, pl. 43, figs. 15–19.)
——— *plaga* Lalicker and McCulloch, **102,** p. 137, pl. 15, fig. 19. Recent, San Francisco Bay, Ecuador, 10 fathoms.
——— *ramosa* Lalicker and McCulloch, **102,** p. 138, pl. 15, fig. 20. Recent, off Galapagos Islands, 400 fathoms.
——— *scrupula* Lalicker and McCulloch, **102,** p. 141, pl. 16, fig. 25. Recent, Cupica Bay, Colombia, 12 fathoms.
——— *secasensis* Lalicker and McCulloch, **102,** p. 141, pl. 16, fig. 24. Recent, off Socorro Island, Mexico, 20 fathoms.
——— *vola* Lalicker and McCulloch, **102,** p. 142, pl. 16, fig. 27. Recent, off Galapagos Islands, 111 fathoms.
——— *warrenites* Coryell and Rivero, **27,** p. 325, pl. 41, fig. 4. Middle Miocene, Haiti.
——— *yumuriana* Palmer, **123,** p. 116, pl. 17, figs. 3, 4. Upper Oligocene, Cuba.
Triloculina fiterrei Acosta, **1,** p. 25, pl. 4, figs. 6–8. Recent, Gulf of Santa Maria, Cuba. 2½–7 fathoms.
——— ——— ——— var. *meningoi* Acosta, **1,** p. 26, pl. 4, figs. 1–5. Recent, Gulf of Santa Maria, Cuba, 2½–7 fathoms.
Triticites umbonoplicatus Rauser and Beljaev, **137,** p. 9, pl. 2, figs. 1–5; text fig. 1. Upper Carboniferous, Russia.
——— *wyssi* Reichel, **138,** p. 98, pl. 19, figs. 1–6. Upper Uralian, Karakorum, India.
Trochammina pulvillus Crespin and Parr, **29,** p. 308, pl. 12, fig. 6. Permian, New South Wales.
TRYBLIODISCODINA subgen. nov., van der Weijden, **175,** p. 15. Subgenus of *Discocyclina* Gümbel, 1868 (1870). Fam. Discocyclinidae. Subgenotype: *Orthophragmina chudeaui* Schlumberger, 1903, Soc. géol. France Bull., ser. 4, vol. 3, p. 282, pl. 9, figs. 18–20; text fig. E. Eocene (Lutetian).

UMBILICODISCODINA subgen. nov., van der Weijden, **175,** p. 15. Subgenus of *Discocyclina* Gümbel, 1868 (1870). Fam. Discocyclinidae. Subgenotype: *Orbitolites discus* Rütimeyer, 1850, Soc. helvétique sci. nat. Nouv. Mém., vol. 11, Mém. no. 2, p. 116, pl. 5, figs. 70, 71, 81. Eocene (Lutetian).

Uvigerina bermudezi Acosta, **3,** p. 5, pl. 1, fig. 8. Recent, off the coast of Cuba, 810 fathoms.
——— *laviculata* Coryell and Rivero, **27,** p. 343, pl. 44, fig. 24. Middle Miocene, Haiti.
——— *quadrata* Coryell and Rivero, **27,** p. 343, pl. 42, fig. 27. Middle Miocene, Haiti.

Vaginulina complanata (Reuss, 1863) var. *perstriata* Tappan, **161,** p. 108, pl. 16, fig. 25. Lower Cretaceous, Texas.
Valvulineria collis Coryell and Rivero, **27,** p. 338, pl. 43, fig. 24. Middle Miocene, Haiti.
Virgulina fusiformis Cushman, 1930, var. *yumuriana* Palmer, **123,** p. 296, pl. 52, fig. 14. Upper Oligocene, Cuba.

Wedekindellina dutkevitchi Rauser and Beljaev, **137,** p. 21, pl. 4, figs. 4–7; text fig. 5. Middle Carboniferous, Samara, Russia.

LIST OF FORMS WITH NOMENCLATURA APERTA

The following forms have not been determined specifically by their authors. As some of them may later be found to be new species they are recorded here separately. In former indexes they have been included with the list of new species.

Angulogerina sp., Israelsky, **86,** p. 577, pl. 4, fig. 7. Eocene, California.
Bolivina sp.(*?*), Cushman and Henbest, **41,** p. 53, pl. 9, fig. 24. Pleistocene, North Atlantic sea bottom.
Bolivinita (*?*) sp.(*?*), Cushman and Henbest, **41,** p. 53, pl. 9, fig. 16. Pleistocene, North Atlantic sea bottom.
Bulimina sp. *A*, Israelsky, **86,** p. 576, pl. 6, fig. 9. Eocene, California.
——— sp. *B*, Israelsky, **86,** p. 577, pl. 6, fig. 8. Eocene, California.
Bullopora sp., Tappan, **161,** p. 115, pl. 18, fig. 7. Lower Cretaceous. Texas.
Cibicides sp., Israelsky, **86,** p. 580, pl. 7, fig. 7. Eocene, California.
Darbyella sp., Coryell and Rivero, **27,** p. 335, pl. 41, fig. 10. Miocene, Haiti.
Dentalina sp., Cushman, **33,** p. 57, pl. 10, fig. 13. Eocene, Alabama.
——— sp., Cushman, **33,** p. 58, pl. 10, figs. 20, 21. Eocene, Alabama.
——— sp., Cushman, **34,** p. 86, pl. 15, fig. 7. Upper Cretaceous, Trinidad, B. W. I. [For: *Dentalina catenula* Cushman and Jarvis, 1932 (not Reuss, 1860), U. S. Nat. Mus. Proc., vol. 80, art. 14, p. 29, pl. 9, fig. 8.]
——— sp., Tappan, **161,** p. 102, pl. 16, fig. 4. Lower Cretaceous, Texas. [For: *Nodosaria filiformis* Carsey, 1926 (not d'Orbigny, 1826), Texas Univ. Bull. 2612, p. 33, pl. 7, fig. 8.]
——— sp., Israelsky, **86,** p. 576, pl. 3, figs. 12, 13. Eocene, California.
Discocyclina (*Asterocyclina*) sp., Rao, **132,** p. 415, text fig. 2. Priabonian, Burma.
Ellipsonodosaria sp., Cushman, **33,** p. 70, pl. 12, figs. 1, 2. Eocene, Alabama.
Elphidium incertum (Linné, should be Williamson, 1858) n. subsp. Schenck, **148,** p. 1761, text fig. 4. Recent, Pacific, San Francisco Bay.
Entosolenia sp., Cushman, **33,** p. 68, pl. 11, fig. 24. Eocene, Alabama.
Epistomina sp., Israelsky, **86,** p. 578, pl. 6, fig. 5. Eocene, California.
Eponides sp., Cushman, **33,** p. 71, pl. 12, fig. 8. Eocene, Alabama.
Frondicularia sp., Tappan, **161,** p. 111, pl. 17, figs. 13, 14. Lower Cretaceous, Texas.
Gaudryina sp., Cushman, **33,** p. 53, pl. 9, fig. 5. Eocene, Alabama.
——— sp., Israelsky, **86,** p. 572, pl. 1, fig. 5; pl. 2, fig. 1. Eocene, California.
Guttulina sp., Cushman, **33,** p. 63, pl. 11, fig. 7. Eocene, Alabama.
——— sp., Israelsky, **86,** p. 576, pl. 7, fig. 1. Eocene, California.
Hemicristellaria sp., Israelsky, **86,** p. 574, pl. 3, figs. 6, 7. Eocene, California.
Lenticulina sp., Israelsky, **86,** p. 572, pl. 2, figs. 4, 5. Eocene, California.
Lepidocyclina (*Polylepidina*) sp., Rao, **132,** p. 415, text fig. 1. Priabonian, Burma.
Lepidorbitoides sp., Rao, **131,** p. 125, text fig. 4. Upper Cretaceous, India.
Liebusella sp. (*?*), Ellisor, **60,** p. 468, pl. 3, fig. 6. Miocene, Louisiana.
Marginulina sp., Cushman, **33,** p. 56, pl. 9, fig. 19. Eocene, Alabama.
——— sp., Cushman, **33,** p. 56, pl. 9, fig. 20. Eocene, Alabama.
——— sp., Israelsky, **86,** p. 575, pl. 4, fig. 13. Eocene, California.
——— sp. *A*, Tappan, **161,** p. 101, pl. 15, fig. 12. Lower Cretaceous, Texas.
——— sp. *B*, Tappan, **161,** p. 101, pl. 15, fig. 13. Lower Cretaceous, Texas. [For: *Cristellaria bronni* Reuss, 1863 (not Roemer, 1840, *Planularia*), Sitzber. Akad. Wiss. Wien, vol. 46, p. 70, pl. 7, fig. 13.]
Nodosaria sp. *A*, Israelsky, **86,** p. 575, pl. 3, fig. 11. Eocene, California.
——— sp. *B*, Israelsky, **86,** p. 575, pl. 5, fig. 5. Eocene, California.
Nonion sp. (*?*), Cushman and Henbest, **41,** p. 53, pl. 9, fig. 15. Pleistocene, North Atlantic sea bottom.
——— sp., Israelsky, **86,** p. 576, pl. 7, fig. 2. Eocene, California.
Nummoloculina sp., Heim, **75,** p. 325, text fig. 5. Upper Cretaceous, Mexico.
Orbitocyclina sp., Rao, **131,** p. 124. text figs. 1–3. Upper Cretaceous, India.
Parafusulina spec. indet., Reichel, **138,** p. 102, pl. 19, fig. 12. Upper Uralian, Karakorum, India.
Planularia sp., Israelsky, **86,** p. 574, pl. 3, figs. 2, 3. Eocene, California.
Palmula sp., Israelsky, **86,** p. 576, pl. 4, fig. 10. Eocene, California.
Polymorphina sp., Cushman, **33,** p. 64, pl. 11, fig. 8. Eocene, Alabama.
?Pseudoclavulina sp., Israelsky, **86,** p. 572, pl. 1, fig. 6. Eocene, California.
Pseudoglandulina sp., Tappan, **161,** p. 105, pl. 16, fig. 14. Lower Cretaceous, Texas.

Pseudopolymorphina sp., Cushman, **33,** p. 64, pl. 11, fig. 9. Eocene, Alabama.
Pulvinulinella sp. *A*, Cushman and Henbest, **41,** p. 54, pl. 10, fig. 5. Recent, North Atlantic sea bottom, off Newfoundland.
——— sp. *B*, Cushman and Henbest, **41,** p. 54, pl. 10, fig. 6. Recent, North Atlantic sea bottom, off Newfoundland.
Ramulina sp., Tappan, **161,** p. 114, pl. 18, fig. 4. Lower Cretaceous, Texas.
Robulus sp., Cushman, **33,** p. 55, pl. 9, fig. 23. Eocene, Alabama.
——— sp., Cushman, **33,** p. 56, pl. 9, fig. 25. Eocene, Alabama.
——— sp., Israelsky, **86,** p. 573, pl. 2, fig. 10. Eocene, California.
Saracenaria sp., Cushman, **33,** p. 61, pl. 9, fig. 32. Eocene, Alabama.
Sigmomorphina sp., Palmer, **123,** p. 288, pl. 51, fig. 15. Upper Oligocene, Cuba.
Textularia sp., Israelsky, **86,** p. 571, pl. 1, fig. 2. Eocene, California.
Textulariella? sp., Palmer, **123,** p. 121, pl. 18, figs. 2, 3. Upper Oligocene, Cuba.
Uvigerina sp. *A*, Cushman and Henbest, **41,** p. 53, pl. 9, fig. 26, Pleistocene, North Atlantic sea bottom.
——— sp. *B*, Cushman and Henbest, **41,** p. 53, pl. 9, fig. 27. Pleistocene, North Atlantic sea bottom.
——— sp. *C*, Cushman and Henbest, **41,** p. 53, pl. 9, fig. 28. Pleistocene, North Atlantic sea bottom.
——— sp. *D*, Cushman and Henbest, **41,** p. 53, pl. 9, fig. 29. Pleistocene, North Atlantic sea bottom.
Vertebralina sp., Palmer, **123,** p. 125, pl. 17, fig. 17. Upper Oligocene, Cuba.

NOMINA NUDA

When studying the publications issued during 1940 the writer noted some names which may not have been published as valid species or varieties, according to the International Rules of Zoological Nomenclature. They are regarded here as *nomina nuda*, until the complete reference will be available.

In the faunal lists of Rauser-Cernoussova, **136,** occur the following names (table 1, pp. 42–43):
Pseudofusulina concavatus Vissarionova.
——— *concessa* Vissarionova.
——— *jaroslavkiensis* Vissarionova.
——— *paraverneuili* Vissarionova.
——— *pedisequa* Vissarionova.
——— *schellwieni* Vissarionova.
——— ——— ——— var. *rara* Vissarionova.
——— *tastubensis* Vissarionova.
——— *verneuili* (Moeller) var. *infecta* Vissarionova.

In Khramov, **92,** p. 11, the following *nomen nudum* is cited: *Saracenaria pravoslavlevi* Fursenko, nom. manuscr.

O. Wetzel's new genus PSEUDASTRORHIZULA and its genotype *P. eisenacki*, apparently published during 1940, could not be traced by the writer.

SUPPLEMENT TO INDEX FOR 1939

The following species and varieties should be added to the index for 1939:
Doliolina dyhrenfurthi Doutkevich, in Licharew, **214,** p. 42, pl. 4, figs. 3–5. Permian, Russia.
Nankinella caucasica Doutkevitch, in Licharew, **214,** p. 34, pl. 1, figs. 16–18. Permian, Arax Valley, Transcaucasus, Russia.
Orobias mirabilis Doutkevitch, in Licharew, **214,** p. 32, pl. 1, figs. 5–9. Permian, Pamir-Takhtabulat section, Russia.
Parafusulina pseudojaponica Doutkevitch, in Gorsky, **209,** p. 43, pl. 5, figs. 4–7. Upper Carboniferous, Darwas, Russia.
Pisolina abichi Doutkevitch in Licharew, **214,** p. 35, pl. 1, figs. 19, 20. Permian, Arax Valley, Transcaucasus, Russia.
Polydiexodina darwasica Doutkevitch, in Licharew, **214,** p. 40, pl. 3, figs. 9, 10. Permian, Darwas, Russia.
Pseudoschwagerina tumida Licharew, **214,** p. 41, pl. 4, figs. 1, 2. Permian, Russia.
Schwagerina globulariformis Doutkevitch, in Licharew, **214,** p. 38, pl. 1, fig. 27; pl. 2, figs. 1, 2. Permian, Russia.
——— *pailensis* (Schwager, 1883) var. *fergananensis* Doutkevitch, in Gorsky, **209,** p. 43, pl. 5, figs. 1, 2. Upper Carboniferous, Ferghana, Russia.
——— *wanneri* (Schubert, 1915) var. *sutchanica* Doutkevitch, in Licharew, **214,** p. 39, pl. 3, figs. 4, 5. Permian, Russia.
Sumatrina ussurica Doutkevitch, in Licharew, **214,** p. 46, pl. 5, figs. 9–12. Permian, Russia.

SUPPLEMENT TO INDEX FOR 1940

During the last few months the following titles of publications dealing with Foraminifera have come to my attention, although I was unable to canvass their contents as to exact citation of page, plate, figure, and age of the new forms.

BUCHNER, PAUL, Die Lagenen des Golfes von Neapel und der marinen Ablagerungen auf Ischia. (Beiträge zur Naturgeschichte der Insel Ischia, I.): Nova Acta Leopoldina, Kais. Leopold.-carol. Akad. Naturforscher, Abh., neue Folge, vol. 9, no. 62, pp. 363–560, 2 pls. (=No. 185 for the year 1940).

In this paper the following 113 new species and 9 new varieties were erected: *Lagena aequilabialis; L. aequilibrata; L. ampullacea; L. arata; L. arquata; L. artificiosa; L. aureoligera; L. aurifera; L. aurifera* Buchner, 1940, var. *connectens; L. benevestita; L. bursiformis; L. caelata; L. cavea; L. cincta; L. circumfossa; L. circumvallata; L. citriformis; L. clavigera; L. compta; L. confirmata; L. cordiformis; L. cornigera; L. corrosa; L. costae; L. crassa; L. cribrata; L. cristigera; L. crustosa; L. crustosa* Buchner, 1940, var. *devia; L. cucullifera; L. cuniculifera; L. curvans; L. decipiens; L. defiorei; L. deformata; L. denticulifera; L. diaphana; L. distycha; L. diversa; L. dohrni; L. earlandi; L. eburnea; L. fabiformis; L. fallax; L.*

fistulifera; L. folioformis; L. fornasinii; L. fovigera; L. frangens; L. furcillifera; L. georgii; L. gibbera; L. granifera; L. granifera Buchner, 1940, var. *trimarginata; L. gratiosa; L. guttata; L. guttula; L. habenifera; L. hamigera; L. heron-alleni* (preoccupied by Earland, 1934); *L. hiulca; L. humilis; L. immoderata; L. jasolini; L. laevigata* (Reuss) var. *labiata; L. laguncula; L. lecythiformis; L. lentiformis; L. marmoraria; L. mazarensis; L. mennellae; L. micans; L. milianae; L. molesta; L. neglecta; L. neptuni; L. nucelloides; L. nucelloides* Buchner, 1940, var. *corrosa; L. nummiformis; L. obesa; L. oblectans; L. ollula; L. orbignyana* (Seguenza) var. *rhumbleri; L. orbitifera; L. pirellii; L. piriformis; L. pretiosa; L. pseudoglobosa; L. pseudomarginata; L. pseudomarginata* Buchner, 1940, var. *benecincta; L. pseudoorbignyana; L. pseudoorbignyana* Buchner, 1940, var. *tumulosa; L. pulviniformis; L. punctatissima; L. punctigera; L. pustulata; L. recurrens; L. reflectens; L. removens; L. rittmanni; L. robusta; L. saturni; L. scutelliformis; L. seguenzae; L. serica; L. sidebottomi* (preoccupied by Earland, 1934); *L. silvestrii; L. simplex; L. solenandri; L. spathiformis; L. staphylleria* (Schwager) var. *perforatissima; L. subtilis; L. tigillifera; L. torquens; L. turbiniformis; L. turgida; L. tympanigera; L. tympaniolum; L. uncifera; L. varioperforata; L. vitreola*, and *Lingulina (?) separans.*

All these new names, more of which may already be preoccupied than indicated, are herewith brought to the attention of all workers who are dealing with fossil or recent Lagenidae.

MANUSCRIPT RECEIVED BY THE EDITOR JULY 11, 1942

STAESCHE, K., and HILTERMANN, H., Mikrofaunen aus dem Tertiär Nordwestdeutschlands: Reichsstelle f. Bodenforsch., Abh., neue Folge, vol. 201, 26 pp., 53 pls. (=No. 186 for the year 1940).

Whether this publication, with its many plates does contain descriptions and figures of new forms, is not known to me.

WANNER, Johannes, Gesteinsbildende Foraminiferen aus Malm und Unterkreide des östlichen Ostindischen Archipels, nebst Bemerkungen über *Orbulinaria* Rhumbler und andere verwandte Foraminiferen: Palaeont. Zeitschr., vol. 22, pp. 75–99, pls. 1, 2, 37 text figs. (=No. 187 for the year 1940).

In this paper two new families, two new genera and three new species are described from Mesozoic beds of the Dutch East Indies, namely:

CADOSINIDAE fam. nov., including the genera *Cadosina* Wanner, *Pithonella* Lorenz, *Calpionella* Lorenz, *Orbulinaria* Rhumbler, *Granulosphaera* Derville, and *Cytosphaera* Derville.

CADOSINA gen. nov. with *Cadosina fusca* spec. nov. as genotype, and *Cadosina semiradiata* spec. nov.

STOMIOSPHAERIDAE fam. nov., with STOMIOSPHAERA gen. nov., genotype: *S. moluccana* spec. nov.

This supplement brings the total of new foraminifera erected during 1940 so far to: 4 families, 1 subfamily, 14 genera, 11 subgenera, 370 species, 50 varieties, and more than 14 homonyma.

JOURNAL OF PALEONTOLOGY, VOL. 17, NO. 4, PP. 409–410, JULY 1943

REVIEW

UPPER CRETACEOUS FLORAS OF THE ROCKY MOUNTAIN REGION. 1. Stratigraphy and palaeontology of the Fox Hills and lower Medicine Bow formations of southern Wyoming and northwestern Colorado. 2. Flora of the Lance formation at its type locality, Niobrara County, Wyoming, by Erling Dorf, Carnegie Institution of Washington Publication 508; pt. 1, pp. 1–78, 8 text figs., 19 pls., issued Dec. 12, 1938; pt. 2, pp. 79–159, 3 text figs., 17 pls., issued Oct. 2, 1942; complete, $2.50 paper or $3.00 cloth, postpaid.

This volume by Dr. Erling Dorf describes fossil floras from areas that have interested geologists and paleontologists for many years. Thick sequences of strata, yielding a variety of plant and animal remains, may be seen in the drainage basins of Lance Creek, Niobrara County, and of North Platte River, in Carbon County, Wyoming. Students of these sections have known that somewhere in the succession of sandstones, shales, and lignites the line between the Mesozoic and Cenozoic must be drawn, but opinions regarding the location of this boundary have differed widely and have aroused much discussion. Some of the reasons for these differences of opinion have been (1) the alleged disagreement between the paleozoological and paleobotanical standards, as for example, the debated contemporaneity of Cretaceous dinosaurs and Tertiary plants, (2) the conflicting observations and interpretations of some lithologic changes, unconformities, and erosional irregularities, considered as probable formational boundaries, and (3) the lack of published studies of the fossil plants, carefully segregated stratigraphically, so that those found in the dinosaur-bearing beds could be compared satisfactorily with those from the immediately overlying strata. Dr. F. H. Knowlton's *The Laramie flora of the Denver Basin*, published in 1922, attempted in part to fill this need, but that paper, unfortunately, was based upon an erroneous assumption, namely, that the Laramie formation is the uppermost Cretaceous in the Denver basin. Now, accepting the paleozoological evidence of dinosaurs and some marine and brackish-water invertebrates as indicative of Cretaceous age, it is known that the Upper Cretaceous of the Denver basin extends into the basal part of the Denver formation and Dawson arkose, and is there succeeded by strata containing Paleocene mammals and plants. These new developments, however, do not violate the paleobotanical standard but necessitate a restudy of the Upper Cretaceous flora in that area. To remedy the lack of accurate information concerning the latest Cretaceous and earliest Paleocene floras of the Western Interior, Dr. Dorf and I, independently, have devoted considerable field work to a study of the several typical areas involved. His results, to which in the main I subscribe, are concentrated in these two papers.

Part I reviews the Medicine Bow formation and its flora, which was taken from several localities in southern Wyoming, and from two localities in equivalent strata, hitherto called Laramie, east of Craig, in northwestern Colorado. Dr. Dorf recognizes 64 kinds of plants in this flora. Of these, 47 were previously described, 11 are new species, and 6 are not specifically determinable. After comparing this assemblage with floras from strata lying conformably above the Fox Hills sandstone in other areas he concludes:

> The age of the lower Medicine Bow formation is rather definitely established by its stratigraphic position, its relation to the *Sphenodiscus* zone and to *Triceratops*-bearing beds, and its associated fresh-water molluscs. The Laramie and lower Lance (Hell Creek member) floras are shown to be most nearly similar to that of the lower Medicine Bow and are considered essentially contemporaneous.

With the Paleocene flora of the overlying Fort Union formation he found only 2 species in common.

Part 2 describes the flora of the Lance formation exposed in the type area on Lance Creek. This flora comprises 70 forms, of which 56 had been described previously, 5 are new species, and 9 are not specifically determinable. Comparing this flora with those from other localities similarly situated stratigraphically, Dr. Dorf concludes that it constitutes an Upper Cretaceous assemblage of which probably less than 10 percent survived as such in the Paleocene.

An examination of the well-prepared illustrations of these floras impresses one with

the fact that only a few Upper Cretaceous leaves, fruits, and seeds suggest unmistakable living counterparts. These include one or two ferns, an araucarian, a sequoia, several palms, water-lilies, a katsura, and a grape. A Paleocene landscape, however, in the same area probably looked relatively modern with many species of plants that would have seemed familiar to a person acquainted with the present floras of the northern hemisphere. By comparing the leaf characters and composition of the Medicine Bow and Lance floras with those of living floras, Dr. Dorf infers that the indications "point toward humid lowland conditions of growth under a warm temperate to subtropical climate."

Probably no paleontologic work can ever be called perfect or complete, because the geologic record is fragmentary, and because new fossil localities with better material may be discovered. Thus, all these floral studies will doubtless receive emendations from time to time. Nevertheless, Dr. Dorf's descriptions of the Medicine Bow and Lance floras begin to clarify the somewhat cloudy situation in regard to Upper Cretaceous floras of the Western Interior, and paleobotanists now have an authentic standard, from the Lance Creek area particularly, that should quell further disputation and should serve as a useful reference for the revision of other contemporaneous or related floras.

As a practical consequence of his floral and stratigraphic studies of the Lance formation, Dr. Dorf, following the example of the paleozoologists in subdividing the Tertiary, proposes that, inasmuch as there is no "clearly defined temporal term for the latest Cretaceous of the Rocky Mountain region," the term "Lancian" be adopted to cover Lance time. In view of the historical connotations associated with the typical Lance formation as well as its rich content of fauna and flora, this suggestion deserves favorable consideration.

ROLAND W. BROWN, U. S. Geological Survey

PALEONTOLOGICAL NOTE

LECTOSYNTYPE, A NEW TERM FOR TYPE SPECIMENS

During the revision of a species based on syntypes (or cotypes) it may be desirable to limit the specimens on which the species is based to certain of the syntypes which, it is suggested, should be termed lectosyntypes. Examples of the taxonomic value of such suggested type specimens are as follows:

1. If a species is based on syntypes from which it is not desirable to select a lectotype, it may be possible to redefine it by the selection of lectosyntypes.

2. A species may be based on syntypes which consist of several groups of specimens, each group from a different locality. The designation as lectosyntypes of the specimens of one of these groups does not necessarily alter the concept of the species but does clarify its definition and reduce the possibility that it is a composite one.

3. When the syntypes of a species are grouped as from different localities and are all lost, it may simplify subsequent taxonomic procedure if a single type locality is selected and fixed. This is done if the syntypes from one locality are chosen as lectosyntypes.

Definition.—Lectosyntypes are specimens that have been selected from among the syntypes of a species and chosen as the sole definers of that species.

Definitions of the various terms for type specimens are given in the following publications which also include other references.

DAVIES, A. MORLEY, 1920, The rules of nomenclature *in* An Introduction to Palaeontology, London, p. 354.

FRITZ, MADELEINE A., 1941, Catalogue of types in the Royal Ontario Museum of Palaeontology: Contr. Roy. Ontario Mus. Palaeontology, vol. 5, pt. 1.

FRIZZELL, D. L., 1933, Terminology of types: Am. Midland Naturalist, vol. 14, p. 637.

HOWELL, B. F., 1930, Symbols on type specimens. Museum News; (A re-publication, with additions, of committee reports on marking of type-specimens: see Geol. Soc. Am. Bull., vol. 40, p. 215, 1929.)

MAKIYAMA, JIRO, 1937, Discussion of types: Jour. Geol. Soc. Japan, vol. 44, p. 246.

RICHTER, R., 1935, Beschränkung der Typus-Sorten, aber Unterscheidung in Dokumente und Nicht-Dokumente: Senckenbergiana, vol. 17, p. 263.

SCHENK, E. T. and MCMASTERS, J. H., 1936, Procedure in Taxonomy, Stanford, California.

R. G. S. HUDSON

JOURNAL OF PALEONTOLOGY, VOL. 17, NO. 4, PP. 411–416, JULY, 1943

SOCIETY RECORDS AND ACTIVITIES

REPORTS AND MINUTES OF THE SEVENTEENTH ANNUAL MEETING OF THE SOCIETY OF ECONOMIC PALEONTOLOGISTS AND MINERALOGISTS

The seventeenth annual meeting of the Society of Economic Paleontologists and Mineralogists was held at Fort Worth, Texas. The meeting was held in conjunction with The American Association of Petroleum Geologists.

The Council of the Society met on Wednesday, April 7. The following Council members and guests were present: president H. L. Driver, past-president H. V. Howe, president-elect J. Harlan Johnson, secretary-treasurer H. B. Stenzel, vice-president Parker D. Trask, and S. G. Wissler (present by invitation).

The Council passed a motion made by S. G. Wissler and seconded by H. B. Stenzel that an article explaining the efficient preparation of manuscript plates be published in the *Journal of Paleontology*.

The Council discussed the desirability of papers concerning smaller Foraminifera and Ostracoda. The Council voted to give such papers preference in publication over other papers and empowered the editor to depart from the sequence of receival date in such cases.

The secretary-treasurer's report for the year 1942 was accepted by the Council.

The annual business session of the Society was held on Wednesday, April 7, at 11:00 A. M., with president Driver in the chair.

President Driver announced the newly elected officers of the Society as follows:

President.....J. Harlan Johnson
Vice-President.....R. Dana Russell
Secretary-Treasurer.....H. B. Stenzel

Minutes of the 1942 meeting were approved as published in the *Journal of Paleontology*, Volume 16, Number 4 (July, 1942).

The following reports were given:

1. *Report of the Editor of the Journal of Paleontology* (J. Marvin Weller).—

Volume 16 of the *Journal of Paleontology*, issued in collaboration with the Paleontological Society in 1942, contains 793 pages and 118 collotype plates. Published in it are 52 paleontological papers, 26 notes, 6 reviews, 2 bibliographies, and data relating to the activities and memberships of the societies. The March, July, and November issues were prepared by Norman D. Newell, who relinquished his duties as editor on behalf of the Society of Economic Paleontologists and Mineralogists in August. These numbers consist of 393 pages and 48 collotype plates and contain contributions classified as follows:

	Paleozoic	*Mesozoic*	*Cenozoic*
Foraminifera	3	–	3
Ostradoca	4	–	2
Bryozoa	2	–	–
Brachiopoda	2	–	–
Pelecypoda	–	3	–
Gastropoda	1	–	1
Cephalopoda	3	1	–
Trilobita	1	–	–
Vertebrata	1	–	–
Faunas	1	–	1

Two of these papers describe foreign specimens. In addition, one paper is devoted to technique, two to nomenclature, and two are bibliographies.

2. *Report of the Editor of the Journal of Sedimentary Petrology* (W. H. Twenhofel).—

The *Journal of Sedimentary Petrology* appeared in 1942 as Volume 12. It contained 14 articles, 6 reviews, and one obituary. As an aid to authors there were published in the third number of the year some directions to be followed in the preparation of manuscripts submitted to the *Journal* for publication.

Several changes have been made in the *Journal* in the interest of economy. Some of these involved saving materials and others use of lighter paper. The number of staples used for binding was reduced first from three to two and later from two to one. Lighter-weight paper has been used and thus the *Journal* is not so bulky as it previously had been. The editor has received adequate articles to fill the *Journal* so far as existing requirements are concerned. What the future

holds in this respect is not determinable. Enough manuscripts are on hand to publish the next number and some part of the third number of 1943.

3. *Report of the Research Committee* (W. H. Twenhofel, Chairman).—

The research committee of the S.E.P.M. has held no meeting during the year. There has been correspondence between the members and the chairman which resulted in the presentation of a symposium at the annual meeting in Fort Worth, on April 7. The committee, through two subcommittees, is working on two programs of the feasibility of listing, with locations, the type fossils of North American paleontology, and also listing of the type sections of North American stratigraphy together with statements respecting the conditions of exposure in these sections. It is generally assumed that there will be little done by these two sub-committees until the conclusion of the war.

4. *Report of the Secretary-Treasurer* (H. B. Stenzel).—

BACK VOLUME SALES

Back volumes of the *Journal of Paleontology*	$591.80
Back volumes of the *Journal of Sedimentary Petrology*	$106.80

PRINTING AND ENGRAVING BILLS FOR 1942

Journal of Paleontology

	Banta Printing Bills	*Meriden Engraving Bills*	*Total Printing and Engraving Bills*	*S.E.P.M. Total Printing and Engraving Bills*
Number 1 (January)*	$ 876.81	$ 491.59	$1,368.40	
Number 2 (March)	1,035.76	334.43	1,370.19	$1,370.19
Number 3 (May)*	784.21	525.00	1,309.21	
Number 4 (July)	906.79	324.48	1,231.27	1,231.27
Number 5 (September)*	1,015.07	501.42	1,516.49	
Number 6 (November)	895.32	450.77	1,346.09	1,346.09
	$5,513.96	$2,627.69	$8,141.65	$3,947.55
(1941 totals)	($4,690.58)	($1,613.34)	($6,303.92)	($2,951.64)

*Odd numbers paid for by the Paleontological Society.

Journal of Sedimentary Petrology

	Banta Printing Bills
Number 1 (April)	$ 332.31
Number 2 (August)	317.70
Number 3 (December)	271.00
	$ 921.01*
(1941 Total)	($ 961.84)

*Less $27.40—part payment by author.

MEMBERSHIP, MAILING, AND JOURNAL STATISTICS

	March 1943	*March 1942*	*March 1941*
1. S.E.P.M. Membership:			
Active Members	251	264	254
Associate Members	66	74	81
Total	317	338	335
2. *Journal of Paleontology* Mailing List:			
S.E.P.M. Active Members	215	219	220
S.E.P.M. Associate Members	44	48	52
S.E.P.M. Subscribers	255	244	272
P.S. Members	323	336	341
Total	837	847	885

3. *Journal of Sedimentary Petrology* Mailing List:			
S.E.P.M. Active Members	114	127	118
S.E.P.M. Associate Members	19	22	20
S.E.P.M. Subscribers	213	239	242
Total	346	388	380
4. Number of pages in 1942 *Journal of Paleontology*		793 (707, 1941)	
5. Number of plates in 1942 *Journal of Paleontology*		118 (85, 1941)	
6. Total edition of 1942 *Journal of Paleontology*		1300 (1300, 1941)	
7. Number of pages in 1942 *Journal of Sedimentary Petrology*		147 (150, 1941)	
8. Total edition of 1942 *Journal of Sedimentary Petrology*		500 (500, 1941)	
New members from March 1, 1942, to March 1, 1943		4 (11, 1941–1942)	
New associates from March 1, 1942, to March 1, 1943		8 (2, 1941–1942)	
Transfers to active membership, March 1, 1942, to March 1, 1943		9 (6, 1941–1942)	

5. *Report of the Resolutions Committee* (M. C. Israelsky, Chairman).—

Be it resolved that the Society of Economic Paleontologists and Mineralogists extends its thanks to the program committee consisting of R. Wright Barker, C. W. Honess, Charles Ryniker, W. H. Twenhofel, S. G. Wissler, and Gayle Scott, chairman; and to the local arrangements committee consisting of Richard H. Schweers, M. E. Upson, H. H. Bradfield, and Gayle Scott,—the efforts of these committees having made this meeting possible.

The Society regrets the resignation of Norman D. Newell as editor of the *Journal of Paleontology* and appreciates the assuming of this task by J. Marvin Weller. The Society also thanks W. H. Twenhofel for continuing as editor of the *Journal of Sedimentary Petrology.*

Be it further resolved that the membership and officers of the Society of Economic Paleontologists and Mineralogists express their deep appreciation and gratitude to the business committee and the executive committee of The American Association of Petroleum Geologists for their continued generous support of the S.E.P.M.

It was moved, seconded, and carried that all reports be accepted.

It was moved, seconded, and carried that the following amendment to the constitution of the Society, to follow Article V, Section 1, be submitted:

"The Council of the Society shall be empowered to forego an annual stated meeting. In case no annual meeting is held, the newly elected officers shall assume their duties on the first of April of the year following their election."

The presentation of papers began at 9:30 A. M. April 7, with president-elect Johnson in the chair. The following papers were given:

SYMPOSIUM: "The Different Fields of Geology as Aids to the Discovery of Petroleum." Directed by W. H. TWENHOFEL.

RAYMOND SIDWELL, "Sedimentary Petrology."

JOHN EMERY ADAMS, "Paleogeography." (By title)

H. B. STENZEL, "Stratigraphy."

H. V. HOWE, "Use of Paleontology by the Oil Industry." (By title)

PARKER D. TRASK, "Problems of Sedimentation in Relation to the Finding of Oil."

CHARLES E. DECKER, "The Teaching of Paleontology."

ALFRED LOEBLICH AND HELEN TAPPAN LOEBLICH, "New Washita Foraminifera."

CHARLES E. DECKER, "Cambrian Graptolites of Wisconsin and Minnesota."

CHARLES E. DECKER, "Pendent Graptolites of Oklahoma, Arkansas, and Texas."

FINANCIAL STATEMENT, DIVISION OF PALEONTOLOGY AND MINERALOGY, FOR THE YEAR 1942

To the Council,
Society of Economic Paleontologists and Mineralogists.

In continuation of our examinations in prior years we have examined the accounting records of the SOCIETY OF ECONOMIC PALEONTOLOGISTS AND MINERALOGISTS for the year ended December 31, 1942, and now present our report together with the following statements:

Exhibit
- A Statement of Financial Condition, December 31, 1942
- B Statment of Income for the year ended December 31, 1942

Schedule
- 1 Statement of Receipts and Disbursements for the year ended December 31, 1942

In connection with our examination, we reviewed the system of internal control and the accounting procedures of the Society and, without making a detailed audit of the transactions, have examined or tested accounting records of the Society and other supporting evidence, by methods and to the extent we deemed appropriate. Our examination was made in accordance with generally accepted auditing standards applicable in the circumstances and included all procedures which we considered necessary.

Inventory of publications represents approximately 28,900 JOURNALS (exclusive of JOURNALS in excess of complete sets for issues prior to 1942) including certain issues printed at the expense of the Paleontological Society for the years 1935 to 1942, inclusive, stated at appraised values of fifty cents each for JOURNALS printed prior to 1942 or cost to either the SOCIETY OF ECONOMIC PALEONTOLOGISTS AND MINERALOGISTS or the PALEONTOLOGICAL SOCIETY for JOURNALS printed in 1942. The SOCIETY OF ECONOMIC PALEONTOLOGISTS AND MINERALOGISTS has agreed to distribute a portion of its income to the Paleontological Society; the amount accruing to the latter for the year 1942 amounted to $336.80.

In our opinion the accompanying statement of financial condition and related statement of income present fairly the position of the SOCIETY OF ECONOMIC PALEONTOLOGISTS AND MINERALOGISTS at December 31, 1942 and the results of its operations for the year, in conformity with generally accepted accounting principles applied on a basis consistent with that of the preceding year.

(Signed) ARTHUR YOUNG & COMPANY, *Accountants and Auditors*
TULSA, OKLAHOMA
February 1, 1943

EXHIBIT A

STATEMENT OF FINANCIAL CONDITION, DECEMBER 31, 1942

ASSETS

CURRENT ASSETS:		
Demand deposits—		
The First National Bank and Trust Company, Tulsa, Oklahoma	$ 2,423.06	
National Bank of Commerce, Tulsa, Oklahoma	138.70	$ 2,561.76
Savings deposit—		
The First National Bank and Trust Company, Tulsa, Oklahoma		2,187.59
Accounts receivable—		
Printed matter less reserve of $84.00	$ 37.20	
Other	21.47	58.67
TOTAL CURRENT ASSETS		$ 4,808.02
INVENTORY OF PUBLICATIONS—see report		15,770.51
FURNITURE AND FIXTURES	$ 482.60	
Less: Reserve for depreciation	240.72	241.88
TOTAL ASSETS		$20,820.41

LIABILITIES AND SURPLUS

CURRENT LIABILITES:		
Accounts payable		$ 271.86
Accrued taxes		9.31
Amount due to Paleontological Society		336.80
TOTAL CURRENT LIABILITIES		$ 617.97
DEFERRED INCOME:		
Subscriptions to Journals	$ 1,089.50	
Membership dues for 1943 and 1944	641.66	1,731.16
SURPLUS		
Balance, December 31, 1941	$18,368.68	
Net income for the year ended December 31, 1942 (Exhibit B)	102.60	
Balance, December 31, 1942		18,471.28
TOTAL LIABILITIES AND SURPLUS		$20,820.41

Subject to comments in accompanying report

EXHIBIT B

STATEMENT OF INCOME FOR THE YEAR ENDED DECEMBER 31, 1942

OPERATING INCOME:		
Dues and subscriptions—		
Journals of Paleontology and Sedimentary Petrology		$ 752.00
Journal of Paleontology		2,586.50
Journal of Sedimentary Petrology		776.10
		$4,114.60
Sales of back numbers—		
Journal of Paleontology	$ 672.20	
Journal of Sedimentary Petrology	182.50	854.70
Sales of plates and reprints		300.76
Advertising		62.46
		$5,332.52
Less: Proportion of income accrued to Paleontological Society		336.80
		$4,995.72
COSTS AND EXPENSES:		
Cost of printing—		
Journal of Paleontology	$4,006.87	
Journal of Sedimentary Petrology	980.37	
	$4,987.24	
Clerical salaries	756.00	
Office rent	300.00	
Postage and mailing	239.90	
Audit fee	100.00	
Office supplies and expenses	79.14	
Depreciation	48.26	
Taxes	26.18	
Other costs and expenses	109.50	
	$6,646.22	
Less: Increase in inventory of publications	1,688.89	4,957.33
		$ 38.39
NON-OPERATING INCOME:		
Recovery of accounts previously charged off	$ 28.00	
Interest on savings deposit	21.71	
Miscellaneous	14.50	64.21
NET INCOME		$ 102.60

Subject to comments in accompanying report

SCHEDULE 1

STATEMENT OF RECEIPTS AND DISBURSEMENTS FOR THE YEAR ENDED DECEMBER 31, 1942

DEMAND DEPOSITS, DECEMBER 31, 1941			$4,304.30
RECEIPTS:			
Membership dues and subscriptions—			
Year 1942—			
Journals of Paleontology and Sedimentary Petrology	$ 760.00		
Journal of Paleontology	1,291.50		
Journal of Sedimentary Petrology	415.60	$2,467.10	
Years 1943, 1944 and 1945—			
Journal of Paleontology	$ 977.60		
Journal of Sedimentary Petrology	317.10	1,294.70	
Sales of back numbers—			
Journal of Paleontology	$ 506.60		
Journal of Sedimentary Petrology	123.85	630.45	
Sales of plates and reprints		305.48	
Accounts receivable		186.53	
Miscellaneous		543.53	5,427.79
			$9,732.09
DISBURSEMENTS:			
Printing expenses—			
Journal of Paleontology	$2,837.87		
Journal of Sedimentary Petrology	650.01		
Engraving *Journal of Paleontology*	1,109.68	$4,597.56	
Postage and mailing		125.14	
Office rent		300.00	
Clerical salaries		684.90	
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